Indian Science Congress Association

TWENTY-NINTH ANNUAL MEETING

January 2nd, 3rd, 4th, 5th, 6th, 7th, and 8th, 1942

to be held at the

Baroda College, Baroda

PROGRAMME
(Provisional)

CALCUTTA
Indian Science Congress Association,
92, Upper Circular Road.
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1942

Proceedings of the Twenty-ninth Indian Science Congress.

PART I.

CONTENTS.

PROCEEDINGS OF THE TWENTY-NINTH INDIAN SCIENCE CONGRESS.

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Dr. C. G. Pandit	*Convener.*
Dr. G. D. Bhalerao	*Recorder.*
Dr. D. N. Banerjee	*Sectional Correspondent.*
Mr. P. M. Nanavati	*Local Sectional Secretary.*
Mr. M. R. Mahajan	*Elected Members.*
Dr. B. Mukerji	
Lt.-Col. S. S. Sokhey	*Past Presidents who are Ordinary or Honorary Members.*
Lt.-Col. K. R. K. Iyengar	
Bt.-Col. Sir R. N. Chopra	
Sir U. N. Brahmachari	
Rao Bahadur T. S. Tirumurti	
Mr. J. R. Haddow	
Mr. A. C. Ukil	
Dr. M. B. Soparkar	*Past Recorders who are Ordinary or Honorary Members.*
Mr. A. C. Ukil	
Rao Bahadur T. S. Tirumurti	
Prof. S. W. Hardikar	
Capt. S. Datta	
Mr. Phanindranath Brahmachari	
Dr. C. G. Pandit	
Prof. S. Ramakrishnan	

11. Agriculture—

Dr. Nazir Ahmad	*Convener.*
Mr. N. L. Dutt	*Recorder.*
Dr. R. P. Mitra	*Sectional Correspondent.*
Mr. S. S. Bhat	*Local Sectional Secretary.*
Dr. B. P. Pal	*Elected Members.*
Dr. J. S. Patel	
Rao Bahadur M. R. Ramaswami Sivan	*Past Presidents who are Ordinary or Honorary Members.*
Sir T. S. Venkatraman	
Sir T. Vijayaraghavacharya	
Rao Bahadur G. N. Rangaswami Ayyangar	
Mr. M. Afzal Husain	
Mr. A. K. Y. Narayan Aiyer	
Rao Bahadur B. Viswanath	
Rao Sahib T. V. Ramakrishna Ayyar	*Past Presidents who are Ordinary or Honorary Members.*
Rai Sahib Jai Chand Luthra	
Mr. K. Ramiah	
Mr. N. V. Joshi	*Past Recorders who are Ordinary or Honorary Members.*
Rao Bahadur B. Viswanath	
Dr. S. V. Desai	
Dr. A. N. Puri	
Dr. C. N. Acharya	

12. Physiology—

Prof. B. T. Krishnan	*Convener.*
Dr. K. P. Basu	*Recorder.*
Mr. Banbihari Chatterji	*Sectional Correspondent.*
Dr. K. N. Kulshrestha	*Local Sectional Secretary.*
Mr. S. Banerjee	*Elected Members.*
Dr. S. N. Ray	
Prof. W. Burridge	*Past Presidents who are Ordinary or Honorary Members.*
Lt.-Col. S. L. Bhatia	
Bt.-Col. Sir R. N. Chopra	
Prof. N. M. Basu	
Dr. W. R. Aykroyd	
Dr. B. B. Dikshit	

Prof. N. M. Basu	.. ..	
Dr. S. N. Mathur	.. ..	*Past Recorders who are Ordinary or Honorary Members.*
Prof. B. Narayana	.. ..	
Dr. B. B. Dikshit	.. ..	
Dr. B. Mukerji ..	.. ..	

13. Psychology and Educational Science—

Dr. Gopeswar Pal	.. ..	*Convener.*
Prof. B. L. Atreya	.. ..	*Recorder.*
Mr. Suhrid Chandra Sinha	.. ..	*Sectional Correspondent.*
Mr. T. K. N. Menon	.. ..	*Local Sectional Secretary.*
Mr. Kali Prasad ..	.. ..	*Elected Members.*
Dr. Indra Sen ..	.. ..	
Dr. N. N. Sen-Gupta	.. ..	*Past Presidents who are Ordinary or Honorary Members.*
Mr. N. S. N. Sastry	.. ..	
Dr. G. Bose ..	.. ..	
Mr. M. N. Banerji	.. ..	
Dr. S. C. Mitra ..	.. ..	
Mr. J. M. Sen ..	.. ..	
Mr. K. C. Mukherji	.. ..	
Mr. Haripada Maiti	.. ..	
Dr. I. Latif ..	.. ..	
Mr. N. S. N. Sastry	.. ..	*Past Recorders who are Ordinary or Honorary Members.*
Mr. M. N. Banerji	.. ..	
Mr. D. Ganguly ..	.. ..	
Dr. I. Latif ..	.. ..	
Dr. Gopeswar Pal	.. ..	

14. Engineering—

Dr. Anant H. Pandya	.. ..	*Convener.*
Mr. N. V. Modak	.. ..	*Recorder.*
Prof. S. K. Roy ..	.. ..	*Sectional Correspondent.*
Mr. A. C. Sahgal	.. ..	*Local Sectional Secretary.*
Mr. S. P. Chakravarti	.. ..	*Elected Members.*
Mr. N. S. Joshi ..	.. ..	
Mr. C. C. Inglis ..	.. ..	*Past President who is an Ordinary or Honorary Member.*
Dr. Anant H. Pandya	.. ..	*Past Recorder who is an Ordinary or Honorary Member.*

3. LOCAL RECEPTION COMMITTEE.

PATRON:

His Highness Maharaja Sir Pratapsingh Gaekwad, Senakhaskhel, Samsher Bahadur, G.C.I.E., LL.D., Farzande-Khas-E-Daulate-Englishia.

VICE-PATRONS:

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M.R.R. Satya Vrata Mukerjea, B.A. (Oxon), Naib Dewan, Baroda.
Sheth Purushottamdas Harjivandas, Mafatlal Fine Mills, Navsari.
Sheth Navinchandra Mafatlal, Mafatlal Fine Mills, Navsari.
Sheth Jaykrishna Harivallabhdas, Jagdish Mills, Baroda.
Raj Mitra B. D. Amin, Alembic Chemical Works, Baroda.
Datar Sheth Chandulal Keshavlal Parikh, Petlad.
Raj Mitra Datar Sheth Ramanlal Keshavlal, Petlad.
Datar Sheth Bulakhidas Narandas, Petlad.
Ishwarbhai V. Patel, Esq., Baroda.
Sir Homi Mehta, Navsari Cotton & Silk Mills, Navsari.
Russa Mehta, Esq., c/o Sir Homi Mehta, Gaekwar Mills, Billimora.
Sheth Motilal Kashandas, Petlad.
Sheth Shantilal Mangaldas, Ahmedabad.
Sheth M. C. Ghia, Bombay.
Sheth Maganbhai Bhikhabhai Patel, Baroda.
Sheth Anandilal Hiralal, Baroda.
Sheth Todermal Chimanlal Shamalbechar, Baroda.
Sheth Dahyabhai Chimanlal Shamalbechar, Baroda.
Sheth Maganlal Prabhudas, Sidhpur.
Sheth Ishwarbhai Chimanlal, Baroda (Jhaverchand Laxmichand & Co.).
Raj Ratna Girdharlal D. Parikh, Advocate, Baroda.
Sheth Vadilal Lallubhai, Baroda.
Datar Sheth Hasmukhlal Jadia, Baroda.

CHAIRMAN:

H.E. Sir V. T. Krishnamachariar, K.C.I.E., Dewan Saheb, Baroda State, Baroda.

HONORARY LOCAL SECRETARIES:

Dr. K. G. Naik, M.A. (Bom.), D.Sc. (Lond.), F.I.C., F.N.I., Principal, Baroda College, Baroda, and Dean of the Faculty of Technology, University of Bombay.
Mr. R. B. Chandrachud, F.R.C.S. (Eng.), Chief Medical Officer, Baroda State, Baroda.

HONORARY LOCAL TREASURER:

B. N. Mehta, Esq., B.Sc., A.H.B.T.I., Chief Chemist, Public Health Laboratory, Baroda State, Baroda.

DONORS:

The Hon'ble Mr. Justice V. N. Patkar, Baroda.
The Hon'ble Mr. Justice S. A. Sudhalkar, Baroda.

Sheth Manibhai B. Amin, Alembic Chemical Works, Baroda.
Sheth Chhotabhai B. Patel, Baroda.
Sheth Punjabhai Tulsibhai Bakorbhai Amin, Baroda.
Sheth Pashabhai Chhotabhai Patel, Baroda.
M. R. R. Manibhai R. Patel, Chief Engineer, Baroda.
Raj Ratna J. M. Pavri, Advocate, Baroda.
Raj Ratna Manibhai V. Desai, Advocate, Baroda.
R. G. Allan, Esq., Commissioner of Agriculture, Baroda.

MEMBERS OF THE LOCAL RECEPTION COMMITTEE:

Dr. J. M. Mehta, M.A., Ph.D., Commissioner of Education, Baroda.
Raj Ratna Col. S. M. Pagar, Private Secretary to His Highness, Baroda.
Dr. N. V. Pandit, Sanitary Commissioner, Baroda.
Mr. K. R. Dotiwala, Director of Commerce, Baroda.
Sheth Hiralal Chhaganlal, Baroda Chemical Works, Baroda.
Mr. Dahyabhai K. Naik, B.A., LL.B., Retired High Court Judge, Baroda.
Navinchandra C. Parikh, Esq., B.Sc. Tech. (Manch.), Petlad.
B. Maitra, Esq., M.Sc., Calcutta Chemical Works, Panditia Road, Calcutta.
Dr. V. N. Likhite, Deputy Director of Agriculture, Baroda.
Sheth Ramanbhai B. Amin, Alembic Chemical Works, Baroda.
B. N. Patkar, Esq., Advocate, Baroda.
Raj Ratna G. M. Tambe, Advocate, Baroda.
A. S. Pradhan, Esq., Advocate, Baroda.
Dr. Dhirubhai M. Shah, Baroda.
Dr. Venilal N. Mody, Baroda.
Desai, Shah & Co., Baroda.
(Mr. Haribhai R. Desai and Mr. Natwarlal Shah.)
R. B. Dev, Esq., B.A., LL.B., Baroda.
R. H. Anjaria, Esq., B.A., LL.B., Baroda.
G. R. Shethji, Esq., B.A., LL.B., Baroda.
D. M. Parikh, Esq., B.A., LL.B., Baroda.
The Shree Sayaji Vijaya Press (Raj Ratna Maneklal Ambaram Doctor and Mr. Laxmilal Maneklal Doctor), Baroda.
Dr. Ramanlal V. Patel, Baroda.

4. GENERAL.

The Twenty-ninth Meeting of the Indian Science Congress Association was held at Baroda * from January 2nd to January 6th, 1942.

The inaugural meeting was held on Friday, January 2nd, 1942, at 9 A.M. in the Central Hall, Baroda College, Baroda, in the presence of the Patron, His Highness Maharaja Sir Pratapsingh Gaekwad, Senakhaskhel, Samsher Bahadur, G.C.I.E., LL.D., Farzande-Khas-E-Daulate-Englishia. Sir V. T. Krishnamachariar, K.C.I.E., Dewan Saheb, Baroda State, Baroda, Chairman of the Reception Committee, welcomed the delegates in a speech and requested His Highness the Maharaja Saheb of Baroda to open the Session of the Congress. His Highness opened the Congress with a speech and then the President of the Congress, Mr. D. N. Wadia, M.A., B.Sc., F.G.S., F.R.G.S., F.R.A.S.B., F.N.I., delivered his address.

The Sectional Presidential Addresses were delivered as follows:—

Saturday, January 3rd : 9-30 A.M., Engineering; 11-30 A.M., Anthropology; 12 noon, Agriculture.

Sunday, January 4th : 9 A.M., Chemistry; 10 A.M., Botany; 11 A.M., Physics; 12 noon, Mathematics and Statistics; 12-30 P.M., Physiology.

Monday, January 5th : 9 A.M., Psychology and Educational Science; 9-30 A.M., Geology; 10-30 A.M., Medical and Veterinary Research †; 11-30 A.M., Geography and Geodesy; 12 noon, Zoology.

Tuesday, January 6th : 9-30 A.M., Entomology ‡.

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* The meeting was to have been held at Dacca under the auspices of the Centenary Celebrations of the Old Dacca College, but the authorities of the University of Dacca, who extended the invitation abandoned the idea of holding the session of the Congress there in view of the unfortunate situation prevailing in the city. See resolution No. 7 of the Executive Committee on p. 37 of this part of the Proceedings.

Owing to uncertainties of the general situation of the country due to war, the Executive Committee decided to close the session on January 6th instead of on January 8th.

† As the elected President of the Section was unable to attend the session, Dr. G. D. Bhalerao, who was chairman of the meeting, read out the Address.

‡ As the elected President of the Section was unable to attend the session, Dr. T. V. Ramkrishna Ayyar, who was chairman of the meeting, read out the Address.

Symposia and Joint Meetings of Sections were held as follows:—

Saturday, January 3rd:

Discussions on	Held in
11-30 A.M. to 1 P.M.	
(1) 'Co-education' ..	The Section of Psychology and Educational Science.
(2) 'Necessity of a collection of Insects of India.' *	The Section of Entomology.
(3) 'Chromatographic Analysis.'	The Section of Chemistry.
2 P.M. to 4 P.M.	
(4) 'The Use of factorial and incomplete block designs in Agriculture.'	The Joint Meeting of the Sections of Agriculture, Mathematics and Statistics.
(5) 'The sequence of prehistoric cultures in India.'	The Joint Meeting of the Sections of Geology and Anthropology.

Sunday, January 4th:

11-30 A.M. to 1 P.M.	
(6) 'Mineral policy for India'	The Joint Meeting of the Sections of Geology and Geography and Geodesy.
(7) 'Industrial plastics' ..	The Section of Chemistry.
(8) 'Improvement in agricultural implements and machinery.'	The Joint Meeting of the Sections of Agriculture and Engineering.
2 P.M. to 4 P.M.	
(9) 'Essential oils' ..	The Section of Chemistry, in co-operation with the Indian Pharmaceutical Conference.
(10) 'India's position with regard to her sulphur resources.'	The Joint Meeting of the Sections of Chemistry and Geology.

* No materials of this discussion were received for inclusion in Part IV of the Proceedings.

Discussions on	Held in
(11) 'The Racial classification of India.'	The Section of Anthropology.
(12) 'Psychological approach to aesthetics.'	The Section of Psychology and Educational Science.

Monday, January 5th:

11-30 A.M. to 1 P.M.

(13) 'Vocational guidance' ..	The Section of Psychology and Educational Science.
(14) 'The Anthropological approach to the Indian Sociology.	The Section of Anthropology.
(15) 'Physical and Chemical properties of clays and bentonites.'	The Section of Chemistry.

2 P.M. to 4 P.M.

(16) 'Sex Hormones, their chemistry, physiology, pharmacology and therapy.'	The Joint Meeting of the Sections of Chemistry, Physiology and Medical and Veterinary Research.
(17) 'Manufacture of synthetic drugs in India.'	The Section of Chemistry.
(18) 'Factor analysis' ..	The Joint Meeting of the Sections of Psychology and Educational Science, and Mathematics and Statistics.
(19) 'Control of weeds' ..	The Joint Meeting of the Sections of Botany, Agriculture and Entomology.

Tuesday, January 6th:

9-30 A.M. to 11-30 A.M.

(20) 'Manufacture of scientific instruments in India.'	The Joint Meeting of the Sections of Chemistry, Physics and Medical and Veterinary Research.
(21) 'The Utilization of results of agricultural research for increased monetary return to the cultivators.'	The Section of Agriculture.

Popular Lectures were delivered as follows:—

Friday, January 2nd, 1942: 6 P.M.

'Lahul: its people and flora,' by Dr. N. L. Bor, M.A., D.Sc., F.L.S., I.E.S., Forest Botanist, Forest Research Institute, P.O. New Forest, Dehra Dun.

Saturday, January 3rd, 1942: 6 P.M.

'The Human Brain,' by Mr. Brij Mohan Lal, M.B.B.S., M.Sc. (Lond.), Principal, Osmania Medical College, Hyderabad.

Monday, January 5th, 1942: 6 P.M.

'The Mica Industry,' by Dr. J. A. Dunn, D.Sc., D.I.C., F.G.S., F.N.I., Superintending Geologist, Geological Survey of India, 27, Chowringhee, Calcutta.

Tuesday, January 6th, 1942: 6 P.M.

'Science and the National Reconstruction in India,' by Dr. Kewal Motwani, A.M., Ph.D., Theosophical Society, Adyar, Madras.

The following Functions and Entertainments were held in honour of the Members of the Indian Science Congress:—

Saturday, January 3rd: 4-15 P.M., Tea Party at the Alembic Chemical Works; 8-30 P.M. Variety Entertainment in the Central Hall, Baroda College.

Sunday, January 4th: 7 P.M., Reception Committee Dinner in the Science Institute Gardens; 8-30 P.M., Variety Entertainment in the Central Hall, Baroda College.

Monday, January 5th: 4-30 P.M., Garden Party by His Highness Maharaja Sir Pratapsingh Gaekwad, Senakhaskhel, Samsher Bahadur, G.C.I.E., Farzande-Khas-E-Daulate-Englishia in the Public Park Gardens; 8-30 P.M., Variety Entertainment in the Central Hall, Baroda College.

Tuesday, January 6th: 8-30 P.M., Variety Entertainment in the Central Hall, Baroda College.

The following Visits and Excursions were arranged for Members of the Indian Science Congress:—

Saturday, January 3rd: 2-30 P.M., Visit to the Alembic Chemical Works.

Sunday, January 4th: 2-30 P.M., Visit to the Kala-Bhavan Technical Institute.

Monday, January 5th: 2-30 P.M., Visit to Baroda State Library, Museum and Art Gallery.

Tuesday, January 6th: 2-30 P.M., Visit to Agriculture Farm and Palaces.

The following Meetings were held during the Session of the Indian Science Congress:—

THE SECTIONAL COMMITTEES met at (1) 2 P.M. on Friday, January 2nd; (2) 9 A.M. on Saturday, January 3rd; (3) 9 A.M. on Sunday, January 4th; (4) 9 A.M. on Monday, January 5th; (5) 9 A.M. on Tuesday, January 6th, 1942.

THE COUNCIL met at 3-30 P.M. on Friday, January 2nd, 1942.

THE EXECUTIVE COMMITTEE met at (1) 2 P.M. on Thursday, January 1st; (2) 3 P.M. on Sunday, January 4th, 1942.

THE GENERAL COMMITTEE met at 2 P.M. on Monday, January 5th, 1942.

THE SUB-COMMITTEE on 'Science and its Social Relations' met at 2 P.M. on Saturday, January 3rd, 1942.

The following Scientific Societies held their Meetings during the Twenty-ninth Session of the Indian Science Congress:—

1. The Annual Meeting of the National Institute of Sciences of India was held at 3 P.M. on Thursday, January 1st, 1942.

2. The Annual Meeting of the Physiological Society of India was held at 2 P.M. on Friday, January 2nd, 1942.

3. The Annual Meeting of the Institute of Chemistry of Great Britain and Ireland (Indian Section) was held at 2 P.M. on Friday, January 2nd, 1942.

4. The Annual Session of the Indian Statistical Conference was opened at 9-30 A.M. on Saturday, January 3rd, 1942.

5. The Annual Meeting of the Indian Physical Society was held at 2 P.M. on Saturday, January 3rd, 1942.

6. The Annual Meeting of the Indian Psychological Association was held at 2 P.M. on Saturday, January 3rd, 1942.

7. The Annual Meeting of the Entomological Society of India was held at 2 P.M. on Saturday, January 3rd, 1942.

8. The Annual Meeting of the Indian Botanical Society was held at 2 P.M. on Saturday, January 3rd, 1942.

9. The Annual Meeting of the Society of Biological Chemists, India, was held at 2 P.M. on Sunday, January 4th, 1942.

10. The Annual Meeting of the Indian Society of Soil Science was held at 2 P.M. on Monday, January 5th, 1942.

11. The Annual Meeting of the Society of Genetics and Plant Breeding was held at 2 P.M. on Monday, January 5th, 1942.

12. The Annual Meeting of the Indian Chemical Society was held at 3 P.M. on Monday, January 5th, 1942.

13. The Annual Meeting of the Indian Pharmaceutical Association was held at 2-30 P.M. on Tuesday, January 6th, 1942.

14. The Annual Meeting of the Indian Ecological Society was held at 2 P.M. on Tuesday, January 6th, 1942.

5. OPENING PROCEEDINGS.

The Twenty-ninth Meeting of the Indian Science Congress was opened on Friday, January 2nd, 1942, at 9 A.M., by His Highness Maharaja Sir Pratapsingh Gaekwad, Senakhaskel, Samsher Bahadur, G.C.I.E., LL.D., Farzande-Khas-E-Daulate-Englishia, in the Central Hall, Baroda College, Baroda, in the presence of Sir V. T. Krishnamachariar, K.C.I.E., Dewan Saheb of the Baroda State, Baroda, and a large gathering of delegates, members and visitors. Seats were specially reserved for the President, Past Presidents, Sectional Presidents, the Local Secretaries, the Local Treasurer, the General Secretaries, the Treasurer, the Chairman of the Local Reception Committee, and special delegates from foreign Scientific Bodies, and Universities, Learned Societies, Colleges, States and Government Departments in India. Sir V. T. Krishnamachariar, Dewan Saheb of the Baroda State and Chairman of the Local Reception Committee, welcomed the delegates and visitors in a speech as follows:—

It is my privilege to accord a warm welcome to Mr. Wadia and the delegates to the Science Congress. We feel greatly honoured that the Congress is holding its annual session in our City.

2. It is with considerable hesitation that I venture to speak a few words to-day. I have no pretension to a knowledge of science nor have I anything original to say. But in these critical times a layman like myself may be forgiven for giving expression to his thoughts, however crude.

3. Writing in 1934, the great historian, the late Mr. H. A. L. Fisher, concluded his survey of Europe through the centuries with a note of pessimism. He said: 'Europe has now reached a point at which, it would seem, as never so clearly in past history, that two alternative and contrasted destinies await her. She may travel down the road to a new war, or overcoming passion, prejudice and hysteria work for a permanent organization of peace. In either case, the human spirit is armed with material power. The developing miracle of science is at our disposal to use or abuse, to make or to mar. With science we may lay civilization in ruins or enter into a period of plenty and well-being the like of which has never been experienced by mankind'. The world's worst fears have alas! been realized. The insensate ambition and ruthless aggression of the Dictators have involved the world in a war in which all the resources of science are being employed in an orgy of destruction of men in the fighting line and of men, women and children among the civil population: of vast quantities

of material of all kinds: of industrial and residential areas: of great works of public utility and of monuments and works of art—the like of which has not been witnessed in the worst periods of barbarism. The war budgets alone of countries run into astronomical figures; each one of them is sufficient to guarantee to the masses a permanent increase in well-being which is the best guarantee of world peace. Nor is this all. There is a more tragic side of the picture. For many years, persistent propaganda is being carried on in the dictator countries to attack all accepted values in science, morals and religion, with the result that millions are prepared to lay down their lives for false ideals. Science began to attain its best development—and real civilization commenced—only when its truths could be proclaimed and taught without incurring persecution. For this right, many scientists have suffered martyrdom in past ages. At present, however, over a large part of the world, Truth cannot be published or taught if it runs counter to political or other theories. This gives us a measure of the relapse into the dark ages that has occurred under totalitarian regimes. When the war is won, the right of Truth to the first place in the lives of men will have to be fought for and vindicated in these countries and millions of men and women redeemed from an intolerable bondage of mind and soul.

4. Every one will agree that the scientist cannot be blamed for the application of the discoveries of science to war. But the world must be saved from this danger. The question of how this is to be done is agitating earnest minds: and thinkers, approaching it from different standpoints, have arrived at more or less indentical conclusions. I shall give a few examples. In 1937, three young scientists calling themselves 'professional psychologists' edited a book 'Human Affairs' in which the issues are stated thus: 'They (scientists) begin to see that the splendid scientific activity which characterizes our age, the mastery of elemental and natural powers to which we have attained is leading us to a cataclysm whose horror we can only conjecture'. After classifying sciences into two groups—purely physical sciences like chemistry, mechanics, and the human sciences like sociology, psychology, biology, which strive to understand all the processes involved in life, they add, 'A short time ago, every intelligent citizen was loudly singing the praises of the physical sciences whose remarkable growth produced such wonders in matters of material production, transport, communication, and human comfort. To-day he bitterly complains that physical science has radically altered social life, revolutionized our outlook, called our old loyalties into question without offering any solution for the manifold social and personal problems which it generated'. The authors then refer to the 'peculiar disabilities' of the scientist, chief among them being 'the microscopic vision which comes of peering into narrowly

restricted fields of work'. In their view the solution is not to call a halt to all scientific advance. 'Rather must we bend all our forces in a steadfast attempt to make equivalent progress in human affairs—look to human sciences for the solution of our social problems.' A political thinker, Mr. Lionel Curtis, dealing with the same issues from a different angle says: 'In the course of a few generations human beings have learned to control physical forces without acquiring a like measure of control over themselves and their relations to one another'. He pleads therefore for social research, for the study of human relations which 'must go beyond the frontiers of knowledge and enter the realms of wisdom' and which 'misses its final purpose when it fails in the effort to think of life as a whole'. Sir Radhakrishnan expresses the same sentiments when he says that the aim should be 'to insist on the high mission of science and relate it organically to the central purpose of human life and society, to reconcile religious wisdom with scientific achievement'. Acting on views like these, the British Association for Advancement of Science has taken the step of founding a division for the Social and International relations of Science—to deal 'with the effect of sciences on the well-being of the community and reciprocally the effects of social conditions upon advances in science'. This example may perhaps be usefully followed in India.

5. The evil thus calls for not less science but more science—science in the broadest sense of the world, embracing the social sciences, those dealing with human relations—and also philosophy—all working with a common aim and a sense of unity and viewing life as a whole. Only thus can civilization be reshaped so as to enable human personality to reach the fullest development of which it is capable.

6. I now come to our own country. India is fortunate in that it possesses bands of devoted scientists, who are making an outstanding contribution to the well-being of its people, often under enormously difficult conditions and at considerable self-sacrifice. The most serious problem facing us is that of mass poverty. Many millions of the people are living among us at the lowest level of economic efficiency in the world excepting possibly in China. I shall not attempt to give you figures of *per capita* income in India. You all know the estimates. Take an elementary need—food. Dr. Aykroyd has recently shown that a well-balanced diet for the vast majority of the people is possible only if twice as much can be spent on food as at present. Then there is clothing. Here again enquiries lead to the same result—that at least twice the amount now spent should be expended to provide the minimum needs. The raising of the standard of living among this large population and the instilling into it of a desire to live better is a problem of the first magnitude. It calls for many lines of attack. Important among these is

agricultural research. In this field, valuable work is being done under the auspices of the Imperial Council of Agricultural Research. But the finances of this body are exiguous and limit the scope of its usefulness. There can be no doubt that its sphere of work should be expanded by a much more generous allotment of funds. There is then the allied question of agricultural finance to which the Reserve Bank of India is devoting attention. Here too there is need for more detailed research. There again are the hosts of social problems connected with the subject each one of which needs study, the results of which will be useful to those whose task is to administer the ever widening social service activities organized in Provinces and States.

7. The war has given a stimulus to industries and His Excellency Lord Linlithgow has given us an impressive account of the efforts made in India to replace foreign imports. Here again the Government of India have organized research on a very broad basis and this will be of the greatest service to the country even after the war is over. Scientists all over the country are giving invaluable assistance in this development and India has every reason to be grateful to them.

8. We have in India a society constituting over a sixth of the human race and possessing ancient civilizations and inherited traditions and ways of life often embedded in religious beliefs which is attempting the great task of evolving a new order under the impact of modern ideas, preserving at the same time the best elements in its culture. This adjustment is giving rise, as is inevitable, to sociological and other problems of great complexity. These, however, intractable they may at first sight appear, will yield to objective studies conducted in a spirit of detachment. There is here a vast field of research specially for the student of social sciences—the sciences that deal with humanity—and I trust a carefully planned organization will be brought into existence for this purpose.

9. I have spoken at greater length than I originally intended and once again ask for your forbearance.

10. This is the first time the Science Congress meets in a city of the size of Baroda and we request you to excuse shortcomings in the arrangements we have been able to make for your stay here.

11. Let me conclude with our best wishes for a successful session of the Congress and to each one of the delegates a New Year full of increased opportunities of service.

His Highness the Maharaja Saheb of Baroda then addressed the meeting as follows:—

MR. PRESIDENT, LADIES AND GENTLEMEN,

It is my pleasant duty to extend to the President and members of the Indian Science Congress a most cordial welcome to this City. This is the first time that the Indian Science Congress is meeting in Baroda, and I trust you will find your stay here pleasant and profitable.

As compared to Bombay, Calcutta and Madras, we have not so many institutions carrying on scientific research in Baroda. But we have our Science Institute with its technological laboratories, the Sayaji General Hospital with its research laboratories, the Kalābhavan and chemical laboratories attached to the Alembic Chemical Works. We have been doing our best to promote the cause of scientific research, and I feel certain that this conference of eminent scientists here will stimulate our efforts.

I am afraid I should understand but little of your deliberations. I, however, fully realize the importance and value of scientific research. The great mechanical inventions of the last hundred years have revolutionized the world. They have annihilated space and time and shrunk the size of the world. They have considerably increased the material prosperity of the world by increasing the volume of production and relieved human labour of drudgery.

Recent biological researches have also had a great influence on the destinies of the human race. Pasteur's pioneer work with reference to the study of microbes and subsequent researches have brought about a great progress in Medical science. The net result of all these researches is that the average duration of man's life is considerably higher than some decades ago. Applied biology has considerably improved our agriculture just as applied chemistry helps industries.

Though we have in the past neglected Science, we take pride in the fact that in recent years we have produced great scientists like Sir C. V. Raman, Prof. Meghnad Saha, the late Sir Jagadish Bose and the late Mr. Rāmānujam.

One of the most vital questions affecting this country is the application of work done by scientists in laboratories to the daily practical problems which confront us. For this, the Governments concerned and organized industries should evolve suitable machinery.

We have here representatives of all branches of Science. These branches are all interdependent, and the discoveries of one react upon the others. A Congress of this type can bring about greater co-ordination of the work carried on in different branches. 'Society, science and the individual are one indivisible whole.' All your efforts are directed towards one end, and it is, as Bacon says, 'the relief of man's estate'. It is our earnest hope that Science will be an instrument in our hands for bettering the lot of humanity.

I again extend you a cordial welcome in Baroda, and wish you success in your deliberations.

At the end of His Highness the Maharaja Saheb's speech, the President Mr. D. N. Wadia delivered his Address.*

The meeting terminated with votes of thanks to His Highness the Maharaja Saheb of Baroda proposed by Dr. K. G. Naik, Local Secretary, and to the Local Reception Committee proposed by Professor P. Parija, General Secretary.

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* Published in Part II of the Proceedings.

6. OFFICIAL.

A. DELEGATES FROM OUTSIDE INDIA.

British Association for the Advancement of Science.

Dr. A. M. Heron.

American Association for the Advancement of Science.

Prof. B. N. Singh.

B. DELEGATES FROM UNIVERSITIES, LEARNED SOCIETIES, GOVE MENT DEPARTMENTS IN INDIA AND CEYLON.

Agra University.

Prof. Ekanath Banerji.
Prof. C. R. Chaturvedi.
Mr. Athar Ali Khan.
Prof. S. K. Mukerji.
Prof. K. C. Pandya.
Prof. H. L. Rohatgi.
Prof. Bishambhar Dayal Saksena.
Prof. Tota Ram Sharma.
Prof. M. F. Soonawala.

University of Allahabad.

Dr. B. N. Prasad.
Dr. S. Ranjan.
Dr. B. K. Singh.
Dr. G. R. Toshniwal.

Aligarh Muslim University.

Dr. S. M. Tahir Rizvi.
Dr. M. Zaki-Uddin.

Andhra University.

Dr. K. V. Giri.
Mr. M. L. Khorana.
Dr. N. S. Nagendra Nath.
Mr. C. J. Dasa Rao.
Dr. G. Gopala Rao.
Mr. P. Suryaprakasa Rao.
Mr. C. Venkata Rao.
Prof. K. P. Rode.

University of Bombay.

Prof. P. R. Awati.
Dr. B. B. Dikshit.
Mr. N. V. Modak.
Prof. H. J. Taylor.
Dr. K. Venkataraman.

University of Dacca.

Dr. K. Banerjee.
Dr. K. P. Basu.
Dr. M. O. Ghani.
Dr. P. Maheswari.
Mr. K. C. Mukherjee.
Dr. T. Vijayaraghavan.

University of Delhi.

Dr. Ram Behari.
Mr. A. C. Chowdri.
Dr. D. S. Kothari.
Dr. Indra Sen.

University of Madras.

Sri R. Gopala Aiyar.
Sri M. Damodaran.
Mr. George Kuriyan.
Sri N. Sundararama Sastri.

University of Mysore.

Dr. Y. Appaji.
Mr. K. B. Madhava.
Mr. P. R. Jagapathi Naidu.
Mr. B. Kuppuswamy Naidu.
Dr. C. S. Pichamuthu.
Mr. M. Rama Rao.
Dr. B. Sanjiva Rao.
Dr. K. Subba Rao.
Dr. B. R. Seshachar.
Mr. M. Shadaksharaswamy.
Mr. S. Siddappa.
Mrs. R. Sree.

Osmania University.

Prof. B. K. Das.
Dr. Brij Mohan Lal.
Dr. M. Qureshi.
Dr. Syed Abdur Rahman.
Mr. Abdus Salam.
Mr. M. R Saxena.
Prof. M. Sayeed-ud-Din.
Dr. Raziuddin Siddiqi.
Mr. Satyanarayan Singh.

University of the Panjab.

Mr. Nazir Ahmad.
Dr. H. Chaudhuri.
Dr. P. L. Kapur.
Mr. P. Samuels Lall.

University of Travancore.

Dr. H. Subramonia Iyer.
Mr. S. Jones.
Mr. A. O. Mathai.
Dr. U. Sivaraman Nair.
Mr. K. Gopinatha Pillai.
Dr. P. P. Pillai.
Mr. K. Sreedharan Nair.

Indian Research Fund Association.

Lt.-Col. S. S. Sokhey.

Indian Society of Agricultural Economics.

Khan Bahadur Mian Afzal Hussain.
Sir T. Vijayaraghavacharya.

National Institute of Sciences of India.

Prof. S. P. Agharkar.
Prof. J. N. Mukherjee.
Dr. B. Prashad.
Mr. W. D. West.

Royal Asiatic Society, Colombo.

Dr. A. Nell.
Mr. K. Vaithianathan.

Government of Bihar and Patna University.

Mr. Nityananda Chatterji.
Maulavi Muhammad Qamrud Doja.
Mr. K. Mitra.
Dr. Bhrigunath Narayan Singh.

Government of India, Commerce Department.

Sir S. S. Bhatnagar.

Government of the Punjab.

Mr. Muhammad Afzal.
Rai Sahib Jai Chand Luthra.
Khan A. Rahman.
Mr. M. Raja Ram.
Mr. S. Amrik Singh.
Mr. S. Sardar Singh.

Minister of Education, Colombo.

Mr. P. Deraniyagala.

C. FINANCIAL ARRANGEMENTS FOR THE TWENTY-NINTH SESSION.

The Local Reception Committee.

The Local Reception Committee made all local arrangements necessary for the transaction of the scientific work of the meeting and all local arrangements regarding social functions and accommodation of the members of the Congress and the delegates.

The total sum raised by the Local Reception Committee amounted to Rs.17,925-8-11 (*vide* a statement of account published on page 52). The total expenditure amounted to Rs.10,519-3-11.

D. MEETINGS OF THE GENERAL COMMITTEE, THE COUNCIL AND THE EXECUTIVE COMMITTEE OF THE INDIAN SCIENCE CONGRESS ASSOCIATION.

1. MEETING OF THE GENERAL COMMITTEE.

A meeting of the General Committee of the Indian Science Congress Association was held at 2 P.M. on Monday, January 5th, 1942, at Baroda College, Baroda, with Mr. D. N. Wadia, the President, in the chair. The following items of business were transacted:—

1. The minutes (*a*) of the last meeting of the General Committee held at 3-30 P.M. on January 6th, 1941, in the Institute of Agricultural Research, Benares; and (*b*) of the Special Meeting of the General Committee held at 9 P.M. on January 3rd, 1941, in the Institute of Agricultural Research, Benares, to consider the question of Regrouping of Subjects into Sections, were read and confirmed.

2. The President announced the names of the seven Ordinary or Honorary Members elected to the Executive Committee under Rule 14, and of the seven Ordinary or Honorary Members elected to the Council under Rule 18, for the year 1942-43:

Executive Committee.	*Council.*
1. Prof. S. P. Agharkar, Calcutta.	1. Dr. M. D. Avasare, Baroda.
2. Prof. P. N. Ghosh, Calcutta.	2. Prof. B. C. Guha, Calcutta.
3. Prof. P. C. Mitter, Calcutta.	3. Prof. H. K. Mookerjee, Calcutta.
4. Dr. K. G. Naik, Baroda.	4. Dr. C. G. Pandit, Madras.
5. Dr. Baini Prashad, Calcutta.	5. Dr. A. H. Pandya, Sibpur.
6. Prof. B. Sahni, Lucknow.	6. Prof. G. R. Paranjpe, Bombay.
7. Mr. W. D. West, Calcutta.	7. Prof. B. N. Singh, Benares.

3. The President announced at the meeting that the Executive Committee had nominated Pandit Jawaharlal Nehru, the Chairman of the National Planning Committee, as Congress President for the year 1943 and that the nomination was being placed before the General Committee for confirmation.

Resolved that the nomination of Pandit Jawaharlal Nehru as General President for the Session 1943 be confirmed.

4. (*a*) The President announced that the Thirtieth Meeting of the Indian Science Congress would be held at Lucknow under the auspices of the University of Lucknow.

(*b*) The President annouced the names of the Sectional Presidents and Recorders of the Thirtieth Meeting as follows:

Section.	*President.*	*Recorder.*
1. *Mathematics and Statistics.*	Dr. S. C. Dhar, Professor of Mathematics, Nagpur University, Nagpur.	Dr. B. N. Prasad, Allahabad University, Allahabad.
2. *Physics* ..	Dr. H. J. Bhabha, Indian Institute of Science, Bangalore.	Dr. R. C. Majumdar, Bose Research Institute, Calcutta.
3. *Chemistry* ..	Dr. S. S. Joshi, Benares Hindu University, Benares.	Dr. D. D. Karve, Fergusson College, Poona.

Section.	*President.*	*Recorder.*
4. *Geology and Geography.*	Lt.-Col. E. A. Glennie, Survey of India, Dehra Dun.	Dr. C. Pichamuthu, Central College, Bangalore.
5. *Botany* ..	Dr. K. Biswas, Royal Botanic Garden, Sibpur.	Dr. J. C. Sen-Gupta, Presidency College, Calcutta.
6. *Zoology and Entomology.*	Dr. B. N. Chopra, Zoological Survey of India, Calcutta.	Dr. A. B. Misra, Benares Hindu University, Benares.
7. *Anthropology and Archaeology.*	Dr. N. Chakravarti, Deputy Director-General of Archaeology in India, New Delhi.	Dr. A. Aiyappan, Superintendent, Government Museum, Madras.
8. *Medical and Veterinary Sciences.*	Dr. F. C. Minett, Director, Imperial Veterinary Research Institute, Izatnagar.	Mr. G. Panja, School of Tropical Medicine, Calcutta.
9. *Agricultural Sciences.*	Rao Bahadur Y. Ramchandra Rao, Imperial Council of Agricultural Research, New Delhi.	Dr. J. K. Basu, Sugarcane Research Scheme, Bombay.
10. *Physiology*	Dr. B. Narayana, P.W. Medical College, Patna.	Mr. K. Mitra, Officer-in-Charge, Nutrition Research, Patna.
11. *Psychology and Educational Science.*	Dr. B. L. Atreya, Benares Hindu University, Benares.	Mr. S. K. Bose, Psychology Department, Calcutta University, Calcutta.
12. *Engineering and Metallurgy.*	Prof. K. Aston, Professor of Electro-technology, Indian Institute of Science, Bangalore.	Dr. H. L. Roy, College of Engineering and Technology, Jadavpur.

5. The following were elected members of the Sectional Committee for the year 1942-43:

1. *Mathematics and Statistics.*	1. Dr. A. N. Singh, Lecturer in Mathematics, Lucknow University, Lucknow. 2. Prof. V. V. Narlikar, Head of the Department of Mathematics, Benares Hindu University, Benares.
2. *Physics* ..	1. Dr. N. R. Tawde, Lecturer in Physics, Royal Institute of Science, Bombay. 2. Prof. D. V. Gogate, Professor of Physics, Baroda College, Baroda.
3. *Chemistry* ..	1. Dr. M. D. Avasare, Professor of Chemistry, Baroda College, Baroda. 2. Prof. R. C. Shah, Professor of Organic Chemistry, Royal Institute of Science, Bombay.
4. *Geology and Geography.*	1. Mr. P. R. J. Naidu, Department of Geology, Central College, Bangalore. 2. Dr. C. C. Shah, Agricultural Chemist, Baroda State, Baroda.
5. *Botany* ..	1. Dr. A. C. Joshi, Department of Botany, Benares Hindu University, Benares.

	2. Dr. V. G. Phatak, Lecturer in Biology, Baroda College, Baroda.
6. *Zoology and Entomology.*	1. Dr. S. T. Moses, Director of Fisheries, Baroda State, Baroda.
	2. Mr. M. Rahimullah, Department of Fisheries, H.E.H. the Nizam's Government, Hyderabad.
7. *Anthropology and Archaeology.*	1. Dr. (Mrs.) I. Karve, Reader in Sociology, Deccan College, Poona 6.
	2. Dr. B. Bhattacharyya, Director, Oriental Institute, Baroda.
8. *Medical and Veterinary Sciences.*	1. Mr. M. R. Mahajan, Animal Husbandry Officer, Ajmer Marwara.
	2. Mr. P. M. Nanavati, Deputy Chief Medical Officer, S. G. Hospital, Baroda.
9. *Agricultural Sciences.*	1. Dr. V. K. Badami, Deputy Director of Agriculture, Orissa, Cuttack.
	2. Dr. V. N. Likhite, Deputy Director of Agriculture, Northern Division, Mehsana, N. Gujarat.
10. *Physiology* ..	1. Mr. S. Banerjee, Honorary Lecturer, Department of Applied Chemistry, University College of Science, Calcutta.
	2. Dr. R. P. Patel, Superintendent, Research and Control Laboratories, Alembic Chemical Works Co., Ltd., Baroda.
11. *Psychology and Educational Science.*	1. Mr. T. K. N. Menon, Principal, Secondary Teachers' Training College, Baroda.
	2. Dr. G. S. Ghurye, Head of the Department of Sociology, University of Bombay, Bombay.
12. *Engineering and Metallurgy.*	1. Prof. G. C. Mukerjee, Professor of Electrical Engineering, Engineering College, Benares Hindu University, Benares.
	2. Mr. A. C. Sahgal, Principal, Kala Bhavan Technical Institute, Baroda.

Professor B. N. Singh of the Benares Hindu University raised a point of order on the question of validity of votes for election of members to the Sectional Committees as there was no definite check to ensure that only Ordinary and Honorary Members were present in the meeting of the General Committee.

The President permitted the matter to be discussed and as a result the following resolution was unanimously carried:

'Resolved that at future meetings of the General Committee it be insisted that the members present their membership cards at the entrance before entering the meeting place and sign their names in a book kept for the purpose.'

6. The audited accounts for the year ending November 30th, 1941, were approved.

7. The Budget Estimates for the year 1st December, 1941 to 30th November, 1942, were accepted.

The General Secretary reported that the Executive Committee had decided to place Rs.100 at the disposal of the Sub-Committee on 'Science and its Social Relations' for carrying on routine correspondence and Rs.125 at the disposal of Dr. Kewal Motwani for the purpose of printing sufficient number of his address for distribution to the members of the current Session.

8. Considered the following resolution adopted by the Executive Committee in connection with election of General President of the Association and reported it for information of the General Committee (*vide* Rule 15):

'(*a*) The General Secretary shall invite nominations for the office of General President of the Association, two years in advance, by a circular letter to the members of the Council, not later than the 15th of October. Such circular shall include a list of the General Presidents of the past 15 years, and the branches of science in which they had specialized.

Nominations shall reach the General Secretary not later than the 15th of November.

(*b*) The General Secretary shall circulate the nominations received to the members of the Executive Committee for expression of opinion on or before the 30th November. Such opinions shall reach the General Secretary not later than the 15th of December.

(*c*) The nominations, together with the views of members thereon, shall be placed for decision before a meeting of the Executive Committee to be held on the day previous to the commencement of the Session of the Congress.'

Resolved that the Regulation adopted by the Executive Committee be confirmed.

9. Considered the following Rules as modified by the Executive Committee and adopted by the Council for placing before the General Committee for their consideration:

(*a*) *Rule* 4:

The annual subscription of Ordinary Members shall be Rs.10. There shall be an entrance fee of Rs.10 payable at the time of joining.

Ordinary Members of the 29th Session (1941-42) shall not pay any entrance fee so long as they continue to be Ordinary Members without interruption.

Ordinary Members whose membership is interrupted shall either pay arrears or pay a fresh entrance fee.

The subscription shall become due on the 1st February of each year. Ordinary Members paying their dues after the 15th July in any year shall not have the right of voting for that year. Such members shall cease to be Ordinary Members if they fail to pay their subscription by the end of January following.

Instead of—

The annual subscription of Ordinary Members shall be Rs.10. The subscription shall become due on the 1st February of each year and shall only be effective as a payment for Ordinary Membership subscription if received before the 15th July of the year. (Existing Rule.)

(*b*) *Rule* 7.

There shall be three classes of Session Members:—

(*a*) Full Session Members—subscription Rs.12 per Session.
(*b*) Associate Session Members—subscription Rs.6 per Session.
(*c*) Student Session Members—subscription Rs.3 per Session. A Student Member shall not get abstract of papers for more than two Sections which should be indicated while applying for membership.

Instead of—

There shall be three classes of Session Members:—

(*a*) Full Session Members—subscription Rs.10 per Sessio...
(*b*) Associate Session Members—subscription Rs.5 per Session.
(*c*) Student Session Members—subscription Rs.2 per Session.

Dr. K. C. Pandya moved that the consideration of the changes of the Rules be postponed till after the war.

Professor B. N. Singh moved an amendment that the consideration of the modifications be postponed *sine die*.

The amendment of Professor B. N. Singh and the original proposal of Dr. Pandya were put to the vote and the resolution of Dr. Pandya was carried by majority.

The President, therefore, announced that the consideration of the modifications in connection with membership was postponed till after the war.

(*b*) *Rule* 14:

The Executive Committee shall consist of the President, President of the previous Session, President-elect, the two General Secretaries, the Treasurer and ten Ordinary or Honorary Members, elected by the General Committee for a period of two years, one member from each zone retiring annually. Two members shall be elected from each of the five zones:—(1) Headquarters (Calcutta and 20 miles surrounding it), (2) Eastern zone (Bengal, Bihar, Orissa and Assam), (3) Southern zone (Madras Presidency with allied States, Mysore, Hyderabad (Dn.), Travancore and Cochin), (4) Western zone (Bombay Presidency and allied States, Sind, Rajputana, Central Provinces and Berar, Central India States, Kathiawar), (5) Northern zone (United Provinces, Punjab, Delhi, N.W. Frontier Province, Kashmir and States included in the area). Permanent place of business, office or residence shall be the criterion for election from the zone. One member shall be elected annually from each zone. For the purpose of this election any Ordinary or Honorary Member may propose the name of an Ordinary or an Honorary Member for election to the Executive Committee. Such proposal must be seconded by another Ordinary or Honorary Member and must reach the General Secretary before the 15th September. The Executive Committee shall circulate these names, together with such other names, not exceeding three, as it may suggest, to all Ordinary and Honorary Members for election by ballot. The ballot papers will be scrutinized by the President or his nominee and the General Secretaries, and the result of the ballot will be announced at the meeting of the General Committee.

Instead of—

The Executive Committee shall consist of the President, the President-elect for the following year, the two General Secretaries, the Treasurer and seven Members, Ordinary or Honorary, elected by the General Committee. For the purpose of this election any Ordinary or Honorary Member may propose the name of an Ordinary or an Honorary Member for election to the Executive Committee. Such proposal must be seconded by another Ordinary or Honorary Member and must reach the General Secretary before the 15th September. The Executive Committee shall circulate these names, together with such other names, not exceeding three, as it may suggest, to all Ordinary and Honorary Members for election by ballot. The ballot papers will be scrutinized by the President and the General Secretaries, and the results of the ballot will be announced at the meeting of the General Committee. (Existing Rule.)

The geographical division as suggested by the Executive Committee was strongly objected to by the members present. The President, therefore, took the sense of the house which was definitely against geographical division. But in view of giving a fuller consideration to the modifications suggested by the Executive Committee, Dr. K. C. Pandya suggested that instead of dropping the modifications all at once here, they be circulated to the members for their opinion and consideration at the next meeting of the General Committee.

The house unanimously adopted the suggestion of Dr. Pandya.

(c) The General Secretary, Professor P. Parija, pointed out that the following addition of words 'or his nominee' after the word 'President' and before the words 'and the General Secretaries' in the last sentence of Rule 14 and Rule 18 might be considered at this meeting and decision might be taken.

After discussion it was resolved that the addition of the words 'or his nominee' be approved in the Rules 14 and 18.

10. The following votes of thanks were unanimously adopted:

(*a*) A vote of thanks proposed by the President to His Highness Sir Pratapsingh Gaekwad Senakhaskhel, Samsher Bahadur, G.C.I.E., LL.D., Farzande-Khas-E-Daulate-Englishia, Maharaja Saheb of Baroda State, for consenting to be the Patron of the Association for 1942 and for opening the Baroda Session.

(*b*) A vote of thanks to the Baroda College and its Principal proposed by the President.

(*c*) A vote of thanks to the Government of Baroda proposed by Professor P. Parija, General Secretary.

(*d*) A vote of thanks to the Chairman and Members of the Local Reception Committee proposed by Professor P. Parija.

(*e*) A vote of thanks to the Local Secretaries and the Volunteers proposed by Professor P. Parija.

(*f*) A vote of thanks to the Treasurer of the Local Reception Committee proposed by Professor P. Parija.

(*g*) A vote of thanks to the President proposed by Professor B. N. Singh.

(*h*) A vote of thanks to the General Secretaries proposed by Professor S. P. Agharkar.

(*i*) A vote of thanks to the Treasurer proposed by Dr. H. Chaudhuri.

2. Meeting of the Council.

A meeting of the Council of the Indian Science Congress Association was held at 3-30 P.M. on Friday, January 2nd, 1942, at Baroda College, Baroda, with Mr. D. N. Wadia, the President, in the chair. The following items of business were transacted:

1. The minutes of the meeting of the Council held on January 2nd, 1941, were read and confirmed.

2. Considered the modifications of Rules finally proposed by the Executive Committee for placing before the General Committee.

Resolved that the recommendations of the Executive Committee be approved with the addition of the following at the end of Rule 4:

'Such members shall cease to be Ordinary Members if they fail to pay their subscriptions by the end of January following.'

Regarding the Regulation in connection with the election of General President, Dr. Nazir Ahmad suggested that instead of inviting nominations from the members of the Council and subsequently voted on by the members of the Executive Committee, the Executive Committee should nominate three names and these names should be voted on by the Council.

As this involved a change in Rules Dr. Nazir Ahmad's suggestion could not be taken up at the meeting, but the house expressed the opinion that the Executive Committee should consider Dr. Nazir Ahmad's suggestion.

In view of the above, the Council by a majority of votes accepted the Regulation as adopted by the Executive Committee.

3. Dr. A. H. Pandya suggested that full papers should be printed before the Session.

Dr. Nazir Ahmad in modification of the suggestion of Dr. A. H. Pandya proposed that the full papers be cyclostyled and distributed at the Section.

In view of the high cost and various difficulties involved in printing or in cyclostyling the full papers the Council after discussion decided that the authors, whose papers would be accepted by the President, be requested to send 20 typed copies of their papers, if possible, so that the members of the Section attending the Session may have the benefit of reading the papers beforehand and taking effective parts in discussion of the papers.

4. Mr. W. D. West brought to the notice of the Council and raised the question of the difficulty created by the clash between the main Session of the Indian Science Congress and the Annual Statistical Conference, which is being held at the same time and place of the Indian Science Congress.

After a long discussion the Council generally favoured the suggestion of Dr. M. Qureshi that at the time of accepting invitations the Executive Committee should convey to the inviting body that no other Conference should be invited to hold its session at the same time as that of the Session of the Congress.

4. Meetings of the Executive Committee.

Eight meetings of the Executive Committee were held during the year 1941-42. The following were among the important items of business transacted:

1. Khan Bahadur Mian M. Afzal Husain and Professor S. K. Mitra were nominated as Additional Vice-President and as Additional Member respectively of the Council of the National Institute of Sciences of India for the year 1941.

2. Professor S. P. Agharkar was nominated member of the Finance Committee for the Session ending January 31st, 1942.

3. The following resolution adopted by the Section of Anthropology was duly forwarded to the Inter-University Board:

'The Anthropology Section of the Indian Science Congress reiterates the resolution passed at the suggestion of Professor H. J. Fleure at the Jubilee Session of the Indian Science Congress in 1938, and urges on such Indian Universities as have not yet considered the resolution to do so at an early date.

Professor Fleure's resolution ran thus :—This Conference is of opinion that in view of the urgent necessity of intensive study of biological traits and social institutions of primitive as well as advanced peoples and cultures in India, it is essential that the Universities and provincial administrations should make adequate provisions for the teaching of Anthropology.'

4. The following resolution adopted by the Section of Agriculture at the 28th Session (Benares, 1941) was duly forwarded to the Imperial Council of Agricultural Research:

'Resolved, (1) that early and efficient steps be taken through the Imperial Council of Agricultural Research and similar bodies as well as through our Universities to collect together and describe in all aspects the wild species of plants related to the main agricultural crops of the country, and (2) that a Committee consisting of Mr. K. Ramiah, Indore, Sir T. S. Venkatraman, Coimbatore, Dr. B. P. Pal, New Delhi, and two members selected by the Indian Botanical Society be authorized to work out details in this connection and give effect to the first resolution.'

5. Invitations were extended to the following Scientific Bodies requesting to send their representative delegates to the 29th Session of the Indian Science Congress held at Baroda:

(1) British Association for the Advancement of Science, London.
(2) American Association for the Advancement of Science, Washington.
(3) Australian Association for the Advancement of Science, Sydney.
(4) South African Association for the Advancement of Science.
(5) U.S.S.R. Academy of Sciences, Moscow.
(6) Royal Swedish Academy of Sciences, Stockholm.
(7) Imperial Academy of Sciences, Tokyo, Japan.
(8) Pacific Science Association, California, U.S.A.
(9) Canadian Association, Canada.
(10) Science Society of China, China.
(11) Society of Science, Netherlands Indies.

6. Reports of deaths of the following members of this Association were received:

(1) The Hon'ble Sir Shah Sulaiman, M.A., LL.D., D.Sc., F.N.I., Ordinary Member of this Association.
(2) Mr. Guru Saday Dutt, I.C.S., Ordinary Member of this Association.
(3) Dr. B. L. Bhatia, D.Sc., F.A.Sc., F.N.I., Ordinary Member of this Association.

7. As the authorities of the University of Dacca, under whose auspices the 29th Session of the Indian Science Congress was to have been held at Dacca, had abandoned the idea of holding the Session there in view of the unfortunate situation prevailing in the city, the invitation from His Highness the Maharaja Saheb of Baroda to hold the Session there was accepted.

8. His Highness Maharaja Sir Pratapsingh Gaekwad, Senakhaskhel, Samsher Bahadur, G.C.I.E., LL.D., Farzande-Khas-E-Daulate-Englishia, was appointed Patron for the 29th Session of the Indian Science Congress at Baroda in 1942.

9. Dr. K. G. Naik, Acting Principal, Baroda College, Baroda, and Mr. R. B. Chandrachud, Chief Medical Officer, Medical and Health Department, Baroda State, Baroda, were appointed Local Secretaries and co-opted as members of the Executive Committee for the 29th Session of the Indian Science Congress held at Baroda in 1942.

10. At the invitation of the All-India Oriental Conference, Professor B. K. Das, D.Sc. (London), Professor of Zoology, Osmania University College, Hyderabad-Deccan, Dr. Muzaffaruddin Qureshi, M.Sc., Ph.D., F.N.I., Head of the Chemistry Department, Osmania University College, Hyderabad-Deccan, and Mr. T. P. Bhaskara Shastri, M.A., F.R.A.S., F.N.I., Director, Nizamiah Observatory, Hyderabad, were nominated delegates to represent this Association at the Eleventh Session of the Conference held at Hyderabad from the 20th to the 23rd December, 1941.

11. It was decided that for keeping uniformity of procedure between the election of members of the Sectional Committees (by the General Committee) and the appointment of Sectional Presidents and Recorders (by the Executive Committee), the General Committee need not insist, at the time of election, on the members elected to the Sectional Committees being Ordinary Members.

12. A Sub-Committee consisting of Professor S. P. Agharkar, Professor J. N. Mukherjee, and the General Secretaries was appointed to consider with reference to the relevant portion of the note of Professor B. Sahni regarding change of rules, if any change in the rules is necessary and, if so, to make suitable suggestions.

13. Messrs. Ray & Ray were appointed auditors for auditing the accounts of the Indian Science Congress Association for the year ending 30th November, 1941.

14. The following Regulations were incorporated in the Regulations under Section IV—Executive Committee:

Election of General President.

(*a*) The General Secretary shall invite nominations for the office of General President of the Association, two years in advance, by a circular letter to the members of the Council, not later than the 15th of October. Such circular shall include a list of the General Presidents of the last 15 years, and the branches of science in which they had specialized.

Nominations shall reach the General Secretary not later than the 15th of November.

(*b*) The General Secretary shall circulate the nominations received to the members of the Executive Committee for expression of opinion on or before the 30th November. Such opinions shall reach the General Secretary not later than the 15th of December.

(*c*) The nominations, together with the views of members thereon, shall be placed for decision before a meeting of the Executive Committee to be held on the day previous to the commencement of the Session of the Congress.

15. The following changes in the Rules were recommended by the Executive Committee for consideration of the Council and the General Committee:

(*a*) That the last paragraph of Rule 4 be changed into that as follows:
'The subscription shall become due on the 1st February of each year. Ordinary Members paying their dues after the 15th July in any year shall not have the right of voting for that year.'

(*b*) That the subscription of Student Session Members be retained at Rs.2 per Session with the proviso that 'Student Members shall not get abstracts of papers for more than two Sections which should be indicated while applying for membership'.

(*c*) That in the modification of Rule 14 (i) 'Session' be substituted for 'Year'; (ii) 'One member from each zone retiring annually' be substituted for 'One retiring annually'.

16. The Executive Committee took the following decision in regard to the Sub-Committee on 'Science and its Social Relations':

(*a*) That in recognition of the value of the work done by the Sub-Committee a sum of Rs.100 per annum be placed at the disposal of the Sub-Committee for meeting expenses on correspondence.

(*b*) That the Secretary of the Sub-Committee be authorized to carry on routine correspondence only on collection of information without reference to the Executive Committee; but when any memorandum is to be submitted or any commitment as regards policy and principle is to be made, the previous approval of the Executive Committee must be obtained.

(*c*) That in the programme of the future Sessions the names and the personnel of the Sub-Committee be mentioned at the end of the list of the Sectional Committees.

(*d*) That a grant of Rs.125 be made to Dr. Kewal Motwani, Secretary of the Sub-Committee on 'Science and its Social Relations' towards the expenses of printing of sufficient number of his address, which, when sent to the Indian Science Congress Office, will be distributed, with the other literature of the Congress for the present Session.

(*e*) That one evening during the future Sessions of the Science Congress be set apart for general meeting of the members and delegates for discussion of Science and its Social Relations.

17. Pandit Jawaharlal Nehru was appointed President for the 1943 Session.

5. Sub-Committee on 'Science and its Social Relations'.

The Annual Meeting of the Sub-Committee on Science and its Social Relations of the Indian Science Congress Association was held during the Congress Session at Baroda on January 3, 1942 at 3 P.M. at the Central Hall of the Baroda College. Mr. D. N. Wadia occupied the chair.

1. Dr. Kewal Motwani, the Honorary Secretary of the Sub-Committee presented the annual report which was adopted.

2. On Mr. Wadia's suggestion it was agreed that the Sub-Committee should retain its present status as a Sub-Committee of the Association rather than be converted into a Section.

3. General authority was given to the Honorary Secretary to carry out the objectives of the Sub-Committee in so far as his actions did not commit the Indian Science Congress Association to any policy in advance. It was resolved that in all important matters of policy, the Executive Committee of the Indian Science Congress Association must be consulted previously.

4. It was resolved to approach the Executive Committee for a financial grant for meeting expenses in connection with the work of the Sub-Committee.

5. It was resolved to request the Executive Committee to mention the Sub-Committee under the list of Sectional Committees in the programme of the Session of the Congress.

E. RESOLUTIONS ADOPTED BY SECTIONS.

Sections of Chemistry, Physics, Medical and Veterinary Research.

Members of the Indian Science Congress Association belonging to the Sections of Chemistry, Physics, Medical and Veterinary Research in their joint meeting for the discussion on 'The manufacture of scientific instruments in India', resolved that,—

> 'They were of the opinion that the formation of an Association of the Indian manufacturers of scientific instruments was desirable'.

Section of Anthropology.

Resolved that the study of Anthropology by means of research and teaching be encouraged by the Government of India and the Governments of Provinces and States, Universities of India and the cultured public by providing lecturerships, scholarships and fellowships.

Section of Psychology and Educational Science.

Resolved that the Executive Committee of the Indian Science Congress be requested by the Sectional Committee of the Psychology and Educational Science to take early measures to establish a Psychical Research Institute in India.

Section of Engineering.

Resolved that (*a*) Special representation be made for the Engineering Section on the Executive Committee for at least a period of five years as the Engineering Section was still in its infancy and it was not therefore in a position to secure election to the Executive Committee by open voting. Unless this is done, the work of the Section will not be effective and satisfactory. This may perhaps involve change in the constitution and therefore it is suggested that provision may be made for increasing the strength of the Executive Committee by the co-option of one member from the Engineering Section.

(*b*) The Committee came to the conclusion that it was absolutely necessary to print the papers on Engineering in full and not in an abstract form as done at present in other Sections as suggested by Rao Bahadur N. S. Joshi. The abstracts do not give a correct idea of the nature of the subject discussed in an Engineering paper and consequently members are not able to take part in discussion. It is by discussion and exchange of ideas that the Science of Engineering has progressed and will continue to progress. This suggestion will, no doubt, involve additional expenditure. If, however, this suggestion is not approved on grounds of finance, then it is suggested that the authors of these papers may be allowed to get their papers printed by other institutions before they come for discussion before the Engineering Section of the Congress.

(*c*) It was also suggested to arrange for popular lectures on Engineering subjects at the next Congress Session so that the scientists in other branches and the public in general may understand and appreciate the popular side of Engineering.

F. RULES AND REGULATIONS, INDIAN SCIENCE CONGRESS ASSOCIATION.

RULES.

1. The name of the Association shall be the Indian Science Congress Association, and its object shall be the advancement of Science in India by the annual holding of a Congress and the doing of all such things as are incidental or conducive to the above object, including—

  (*a*) the holding and management of funds and property;
  (*b*) the acquisition of rights and privileges necessary or convenient for the object of the Association;
  (*c*) the management, development, improvement, disposal, and sale of all and any parts of the property of the Association.

2. The Association shall consist of Ordinary Members, Honorary Members and Session Members.

3. Ordinary Members of the Association shall have the right to contribute papers for reading at the Session of the Congress, to receive free of charge all publications issued by the Association, and to fill any office in the Association on being duly elected thereto.

4. The annual subscription of Ordinary Members shall be Rs.10. The subscription shall become due on the 1st February of each year and shall only be effective as a payment for Ordinary membership subscription if received before the 15th July of the year.

5. Any Ordinary Member may compound for the payment of all future annual subscriptions by the payment in a single sum of Rs.150.

6. Honorary Members shall have all the rights and privileges of Ordinary Members.

Honorary Members, the number of whom shall be limited to fifteen at any one time, shall be persons eminent for their contributions to Science or persons who have rendered conspicuous services to the cause of Science in India.

Honorary Members shall be unanimously nominated by the Executive Committee subject to confirmation by the Council and the General Committee at its annual meeting. Not more than one Honorary Member shall be elected in any year.

7. There shall be three classes of Session Members:—

  (*a*) Full Session Members—subscription Rs.10 per Session.
  (*b*) Associate Session Members—subscription Rs.5 per Session.
  (*c*) Student Session Members—subscription Rs.2 per Session.

8. Full Session Members shall have the right to contribute papers for reading at the Session of the Congress, and to receive free of charge all publications issued by the Association relating to the Session of the Congress of which they are Members.

Associate and Student Session Members shall have the right to submit papers for reading at the Session of the Congress of which they are Members, provided such papers be communicated through an Ordinary or an Honorary Member of the Association.

A Student Member shall before admission be duly certified by the head of his Institution to be a *bona fide* student.

Associate and Student Session Members shall receive free of cost the Abstracts of Papers contributed for the Session of which they are members.

9. The official year of the Association shall commence from the 1st of February.

10. There shall be Officers of the Association consisting of the Members of the Executive Committee and Presidents and Recorders of Sections.

11. Only Ordinary and Honorary Members shall hold office in the Association.

12. The term of office of all Officers of the Association except the President shall commence from the beginning of the official year and shall extend until the assumption of office by their successors appointed in accordance with the provisions of these Rules. The President shall assume office on the opening day of the Annual Congress following the one at which he is appointed, and shall continue to hold office until the assumption of office by his successor.

13. There shall be an Executive Committee which shall carry on the administrative work of the Association and submit such questions as it thinks desirable to a General Committee at its Annual Meeting during the Session of the Congress or at a Special Meeting of which due notice shall have been given.

14. The Executive Committee shall consist of the President, the President-elect for the following year, the two General Secretaries, the Treasurer and seven Members, Ordinary or Honorary, elected by the General Committee. For the purpose of this election any Ordinary or Honorary Member may propose the name of an Ordinary or an Honorary Member for election to the Executive Committee. Such proposal must be seconded by another Ordinary or Honorary Member and must reach the General Secretary before the 15th September. The Executive Committee shall circulate these names, together with such other names, not exceeding three, as it may suggest, to all Ordinary and Honorary Members for election by ballot. The ballot papers will be scrutinized by the President or his nominee and the General Secretaries, and the results of the ballot will be announced at the meeting of the General Committee.

The Executive Committee shall co-opt as Members at least one and not more than two Local Secretaries for the ensuing Session of the Congress.

15. The Executive Committee shall have full power to transact all business in cases of emergency, notwithstanding any limitations hereinafter laid down, and to deal with all matters not otherwise provided for in these Rules, including the making of such Regulations as may appear conducive to the good administration of the Association and the attainment of its object; provided always that such Regulations be not inconsistent with anything contained in these Rules, that they be reported for the information of the next meeting of the General Committee, and that they be subject to recission or alteration by the Executive Committee or by any meeting of the General Committee.

16 There shall be a General Committee which shall consist of all Ordinary and Honorary Members of the Association.

17. The General Committee shall meet at least once during each Session of the Congress, perferably, in the middle of the Session.

18. There shall be a Council which shall consist of all Members of the Executive Committee, and all such Ordinary and Honorary Members of the Association as have held office as President, General Secretary, Treasurer, or Managing Secretary of the Association, the Sectional Presidents for the ensuing Session, and in addition seven Members of the Association, Ordinary or Honorary, elected by the General Committee. For the purpose of this election any Ordinary or Honorary Member may propose the name of an Ordinary or an Honorary Member for election to the Council. Such proposal must be seconded by another Ordinary or Honorary Member and must reach the General Secretary before the 15th September. The Executive Committee shall circulate these names, together with such other names, not exceeding three, as it may suggest, to all Ordinary and Honorary Members for election by ballot. The ballot papers will be scrutinized by the President or his nominee and the General

Secretaries, and the results of the ballot will be announced at the meeting of the General Committee.

19. The function of the Council shall be to act as a body of advisers to be consulted by the Executive Committee on important questions of policy or scientific import.

20. There shall be a President who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

21. There shall be two General Secretaries (one of whom shall be resident in Calcutta) who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

22. There shall be a Treasurer who shall be nominated by the Executive Committee and whose nomination shall be submitted for confirmation to the General Committee at its Annual Meeting during the Session of the Congress.

23. The term of office of each General Secretary and of the Treasurer shall be for a period of five years following the confirmation of the appointment of any one of them, and each of them shall be eligible for reappointment.

24. In the event of a vacancy amongst the General Secretaries and the Treasurer occurring between two Sessions of the Congress the Executive Committee shall have power to appoint a General Secretary or the Treasurer for the period up to the termination of the next Session of the Congress.

25. There shall be a Local Secretary or Local Secretaries for each Session of the Congress who shall be appointed by the Executive Committee.

26. There shall be a Local Committee for each Session of the Congress which shall be appointed by the Executive Committee.

27. The Local Secretary, or Secretaries, and the Local Committee shall jointly, on behalf of and in consultation with the Executive Committee make all necessary arrangements for the holding of the Session of the Congress.

28. For the purpose of scientific deliberation during the Session of the Congress there shall be such Sections corresponding to different branches of science as may from time to time be constituted by the General Committee on the recommendation of the Executive Committee. It shall be competent for any Section after the first day's meeting to hold its scientific meetings in sub-sections for the purpose of dealing separately with different groups of papers submitted to that Section. A separate chairman may be appointed by the Sectional President in consultation with the Sectional Committee to preside over each sub-section.

29. There shall be in each Section a President and a Recorder who shall be appointed by the Executive Committee. In addition there shall be a Sectional Correspondent and a Local Sectional Secretary who shall be appointed by the Executive Committee.

30. In each Section there shall be Sectional Officers, namely, a President, a Recorder, a Sectional Correspondent, and a Local Sectional Secretary. The President and the Recorder shall be the chief executive officers of the Section. They shall have power to act on behalf of the Sectional Committee in any matter of urgency which cannot be brought before the Sectional Committee for consideration, and they shall report such action to the Sectional Committee at its next meeting.

The work of each Section shall be conducted by a Sectional Committee which shall be constituted as follows:—

(*a*) Sectional Officers.

(*b*) All Ordinary and Honorary Members of the Association who have been Presidents or Recorders of the Section.

(*c*) Two Members of the Association, Ordinary or Honorary, elected by the General Committee at its Annual Meeting during the Session of the Congress.

The Sectional President shall preside over all meetings of the Section and of the Sectional Committee. He shall be the convener of the meeting of the Sectional Committee. His ruling shall be final on all points of order that may arise.

The Sectional Recorder shall act as the Secretary of the Sectional Committee, and shall maintain a proper record of the proceedings of the Sectional Committee and of the Section in a book provided for the purpose. He shall be responsible for the punctual transmission to the General Secretary of the recommendations adopted by the Sectional Committee, and of resolutions adopted by the Section.

The Sectional Correspondent shall be resident at the head-quarters of the Association, and shall be responsible for preparing for the press the material relating to his Section, according to the instructions of the Sectional President.

The Local Sectional Secretary shall be resident in the locality where the Annual Session is held, and shall be responsible for all local arrangements for the work of his Section, and for arranging the Sectional excursions in consultation with the Local Secretaries.

31. The Sectional Committee shall meet on the opening day of each Session of the Congress, and daily thereafter during the Session before the meeting of the Section unless otherwise determined at a meeting of the Sectional Committee.

In the absence of the Sectional President from any of its meetings the most senior member of the Sectional Committee present shall take the chair.

In their meeting on the opening day they shall

(*a*) nominate a Sectional President and a Sectional Recorder for the ensuing year for the consideration of the Executive Committee;

(*b*) determine the detailed arrangements for the Sectional meeting;

(*c*) select the papers to be read and discussed;

and in their meetings during the Session they shall also

(*d*) nominate a Sectional Correspondent and a Local Sectional Secretary for the ensuing year for the consideration of the Executive Committee;

(*e*) determine the contents of the Sectional records in the Proceedings in accordance with Rule 32(*e*);

(*f*) consider means of improving the scientific work of the Section, and make suggestions to the Executive Committee whenever considered necessary;

(*g*) select topics for discussions at the next Session of the Congress and make necessary arrangements (i) through the President of the Section concerned for discussions within a Section, and (ii) through the Sectional President who has initiated the proposal for a discussion in which more than one Section will participate.

32. (*a*) All papers submitted for reading at the next Session of the Congress shall be forwarded to the General Secretary so as to reach him not later than September 15th of the calendar year preceding the Session of the Congress at which the papers are intended to be read, provided that this date may be changed by the Executive Committee for special reasons.

(*b*) Any paper submitted for reading at the Session of the Congress shall be accompanied by an abstract in triplicate.

(*c*) All papers submitted for reading at a Session of the Congress, shall be checked by the Sectional Correspondent concerned or by such person or persons appointed by the General Secretary. The papers together with a copy each of the abstracts shall then be sent to the Sectional President concerned for refereeing and acceptance. Decisions with regard to acceptance or rejection of any paper shall be final and all reports confidential.

(*d*) No paper published elsewhere shall be accepted.

(*e*) Only abstracts of the paper received by the General Secretary before September 15th in accordance with Rule 32(*a*), (*b*) and (*c*) shall be printed in Part III of the Proceedings. In exceptional circumstances abstracts of papers received after that date and read before the Section if specially recommended by the Sectional Committee, may be printed in Part IV.

33. The Proceedings of the Indian Science Congress Association shall be published in one volume in four separate parts, as follows:—

I. To contain the list of officers, the proceedings of the opening meeting (except the General Presidential Address) and all official matters.

II. To contain the Presidential Addresses. To be distributed to those present at the meeting after the addresses have been delivered, and to absent Ordinary, Honorary and Full Session Members by post after the meeting.

III. To contain the abstracts of papers to be read before the Sections which are received before September 15th in accordance with Rule 32(*a*). No abstracts shall be included in this volume from authors who have not already enrolled themselves as Members of the Association. To be distributed in advance of the Meeting to all Members of the Association.

IV. To contain the discussions, late abstracts accepted in accordance with Rule 32(*e*), the list of members and the index.

34. The following procedure shall be observed for the making of any addition to or alteration in the Rules of the Association:—

(i) Proposals for additions to and alterations in the existing Rules may be placed at any time before the General Committee by the Executive Committee.

(ii) (*a*) Proposals for additions to and alterations in the existing Rules by any Ordinary or Honorary Member of the Association shall be sent to one of the General Secretaries so as to reach him two full months before the meeting of the General Committee in which they are to be moved.

(*b*) One of the General Secretaries shall circulate such proposals to all Ordinary and Honorary Members of the Association at least one full month before the meeting of the General Committee.

(*c*) Any amendments to the proposals shall be sent by any Ordinary or Honorary Member of the Association to one of the General Secretaries so as to reach him at least a fortnight before the meeting of the General Committee.

(*d*) The proposals together with any amendments shall be brought up before the meeting of the General Committee of its Annual Meeting during the Session of the Congress together with any remarks of the Executive Committee and declared carried if accepted by a two-thirds majority of the constituent Members present and voting at the meeting.

(Adopted the 5th January, 1931. Revised the 5th January, 1935, the 6th January, 1936, the 5th January, 1937, the 8th January, 1939, the 6th January, 1940 and the 5th January, 1942).

REGULATIONS.

I. Sectional Officers.

(1) The President delivers a Presidential Address of which ordinarily the cost of printing 25 pages of the Proceedings in its usual form shall be borne by the Indian Science Congress Association. The time available for delivery of the Presidential Address shall usually not exceed 45 minutes. The manuscript of the address, ready for the press, should be received by the General Secretary before October 15th of the calendar year preceding the Session of the Congress at which the address will be delivered, provided that this date may be changed by the Executive Committee for special reasons. It should be accompanied by 12 copies of a short popular summary (about 500 words) for issue to the lay press. The time and date of the delivery of the President's address will be communicated before the meeting of the Congress. No two Presidential addresses will be delivered at the same time.

(2) The President shall be entitled to receive 30 copies of his address without charge, and additional copies at the cost of reproduction.

(3) Railway fares, postage, clerical, or other expenses incurred by the Sectional Presidents will not be paid by the Association.

(4) The following procedure is adopted for the collection of papers for the Sections:—

About the middle of April a number of copies of a printed circular will be forwarded to the President of each Section who may arrange to send these to workers in that branch of science with which his Section is concerned, requesting them to contribute papers for reading before the next meeting of the Congress.

The circular will contain a clause inviting such workers as are not yet Ordinary Members of the Association to join as such. Particular note should be taken of the fact that no new Ordinary Members are enrolled after the 15th July of the year.

In the case of joint papers, each author must be a Member of some category.

(5) The President referees, either in person or by proxy, the papers received for reading before his Section in accordance with Rule 32.

Abstracts should be limited, except in very special cases, to about 200 words. Long abstracts should be reduced by the President. References to literature in abstracts should be avoided as far as possible and when given should conform to the system of abbreviations used by the Association.

The contents of all abstracts should be carefully checked by the Sectional Correspondent concerned or by such person or persons appointed by the General Secretary, and the abstracts shall then be sent to the Sectional President for his final scrutiny and approval.

Joint discussions on related papers may be held. Authors of papers should be informed of the time allotted by the President to the reading of their papers. An author contributing more than one paper should be asked to specify which of them he would prefer to read at the meeting.

(6) The President, in consultation with the Local Sectional Secretary, shall make arrangements for such local Sectional excursions as seem desirable. Due notice shall be given to the General Secretaries of all such arrangements.

(7) The President and Recorder should, in consultation with other members of the Sectional Committee, make proposals to the General Secretary regarding the programme of the Section. Such proposals should reach the General Secretary not later than the 1st November, so as to enable the necessary details to be entered in the programme. General discussions on questions of importance, held either by a single Section or jointly by two or more Sections, should be encouraged.

The Sectional Presidents concerned shall communicate to the General Secretary before the end of July the titles of such discussions, the names of the speakers and such further information as may be considered necessary.

The Papers, together with three copies of abstracts, to be read by the contributors at a discussion shall be sent to the General Secretary on or before the 15th September of the preceding calendar year by the Sectional President concerned.

The materials relating to a discussion, in a form ready for the press, shall be communicated to the General Secretary within a month from the date on which the discussion takes place; the material not received by the General Secretary within this period shall not be published.

The President and the Recorder of the Section arranging a discussion shall carry out the necessary correspondence throughout the year during which they hold office.

(8) Early in November copies of a printed form will be issued to Presidents of Sections for circulation to members of the Sectional Committees requesting them to nominate a President and a Recorder for the ensuing meeting for consideration by the Sectional Committee. Such proposals shall be accompanied by a statement of qualifications of the nominees for the office and their willingness to accept the same if elected thereto.

During the first week of December, the President of each Section shall circulate all such proposals received by him together with the statements of qualifications, to the members of the Sectional Committee and request them to nominate by ballot one member for each office from amongst the list circulated, the ballot papers being received by him up to the 20th December.

At the first meeting of the Sectional Committee held on the Opening Day, the ballot papers shall be opened and scrutinized as the Chairman shall direct and the result communicated to the Executive Committee for consideration, together with a complete record of the Proceedings in this connection.

(9) The duties of the Sectional Correspondent and of the Local Sectional Secretary are given in Rules 30 and 32(*c*).

(10) All persons entitled to be members of the Sectional Committee should enrol themselves without delay as Ordinary Members if not already so enrolled and should inform the General Secretary of the payment of their subscription when accepting the appointment.

(11) The General Secretary should be consulted whenever any question arises not dealt with in these regulations.

II. Local Arrangements.

In accordance with the Rules of the Association, the Local Secretaries and the Local Committee shall jointly, on behalf of and in consultation with the Executive Committee, make all necessary arrangements for the holding of the Session of the Congress.

The following arrangements have to be made:

A. *Accommodation for the Scientific Meetings.*

(1) A large hall should be available for (*a*) the President's address on the opening day, and (*g*) for the evening lectures. Both (*a*) and (*b*) are open to the public free of charge. A projection lantern with an operator should be available in this room, and it is a great advantage if loud speakers can be installed.

(2) Rooms for the meetings of the different Sections of the Congress should be provided and suitably furnished. An epidiascope with an operator should be provided in each sectional room. All the rooms

should as far as possible be in close proximity. The following are the Sections of the Congress:—

Mathematics and Statistics, Physics, Chemistry, Geology and Geography, Botany, Zoology and Entomology, Anthropology and Archaeology, Medical and Veterinary Sciences, Agricultural Sciences, Physiology, Psychology and Educational Science, and Engineering and Metallurgy.

(3) A Reception room should be provided in which Members can get information, write letters, etc. The Local Secretaries' Office should be as near as possible to this room. An arrangement should be made with the Postmaster-General to have a temporary Post Office in this room and for all letters addressed to members c/o The Indian Science Congress to be delivered here. The Indian Science Congress Post Office should be situated as near as possible to the Reception room.

(4) A room near the Reception room should be set apart for the General Secretaries' Office, which will be opened therein from the 31st December.

(5) Provision should be made for lunch in European and Indian styles at moderate charges near the Reception room.

B. *Accommodation for Visiting Members.*

The Local Secretaries should send out, not later than the end of November, a printed circular to all Members enrolled asking them if they desire that accommodation should be arranged for them. It is desirable, as far as possible, to provide private hospitality for the President, Sectional Presidents, and Officers of the Congress. In this circular information should be given regarding the types of accommodation available, with the charges, and the nature of the climate during the Session. The Local Secretaries will receive periodically from the General Secretary list of Members enrolled at headquarters.

C. *Programme of the Meeting.*

(1) (*a*) The Sections of the Congress meet daily in the morning generally from 9-30 A.M.

(*b*) Presidential Addresses of the Sections shall commence from 9-30 A.M.

(*c*) There should be no afternoon Presidential Addresses of the Sections.

(*d*) Symposia or joint discussions will be held either in the morning, or from 2 P.M.

(2) Public lectures are arranged by the Executive committee, and are given at 6 P.M. or 6-30 P.M.

(3) A printed guide with a map of the locality in which the Congress is held should be prepared for distribution to Members on the opening day. Only Ordinary, Honorary and Full Session Members are entitled to the Guide Book free of cost. A small charge not exceeding Re.1 (to be fixed by the Local Committee) may be made to other Members desiring to have a copy. The Guide Book should contain a summary of information concerning the scientific and educational activities and a short history of the locality, in addition to general information likely to be of use to visitors.

(4) Arrangements should be made for giving due publicity to the activities of the Congress, both before and during the meeting.

(5) A list of Members with their local addresses where known should be printed and distributed on the opening day. A supplementary list should be typed and posted in the Reception room and maintained up-to-date. The Local Secretaries shall arrange for this.

(6) A provisional programme of social engagements should be drawn up by the Local Secretaries and sent to the General Secretary by the 25th

November. It is essential that this be sent in time, as it has to be printed and distributed with the abstracts by the first week in December.

The General Secretary will make arrangements for printing the programme drafted as above and distributing these to Members enrolled at the time of the distribution of the abstracts.

The final programme shall be printed locally by the Local Committee in time for the opening of the Session.

D. *General.*

(1) Numbered badges for Members of the Congress will be sent by the General Secretary to the Local Secretaries for distribution on the opening day of the meeting. The badges should bear numbers corresponding to the enrolment numbers. There should be additional badges for Officers.

(2) Members of the Local Reception Committee who have made substantial contributions to the funds of the Local Committee may be given complimentary tickets to attend the meetings.

(3) An audited copy of the accounts of the Local Committee should be sent to the General Secretary not later than the 30th April, following the Session, for inclusion in the Proceedings of the Session. It is desirable that the Local Committee should contribute any surplus to the reserve fund of the Association.

(4) Twelve copies of each of all local publications connected with the Congress (guide book, final programme, notices, cards, etc.) should be sent to the office of the Association for record at the conclusion of the meeting.

(5) Applications for membership will ordinarily be dealt with by the General Secretary at the office of the Association up to the 15th December. After that date applications for membership will be forwarded to the Local Secretaries, who will open a separate account for the sale of membership tickets. The amount thus realized, together with unsold tickets, should be forwarded to the General Secretary immediately after the close of the Congress.

III. Financial.

(1) The accounts of the Association shall be audited once a year and the books closed on the 30th November each year for this purpose.

(2) The audited accounts shall be placed before the General Committee at the Annual Meeting with the observations, if any, of the Executive Committee.

(3) Sanction for all payments for amounts exceeding Rs.100 shall be obtained from the Finance Committee which shall consist of the General Secretaries, the Treasurer, and one Ordinary or Honorary Member resident in Calcutta who shall be nominated by the Executive Committee.

(4) Amounts received on account of Life Membership Subscription shall be credited to the Reserve Fund of the Association.

IV. Executive Committee.

A. *Election by the Executive Committee.*

(1) A letter shall be issued asking for nominations giving a last date therefor.

(2) The proposer should ascertain whether the person he proposes is desirous of serving in that particular capacity.

(3) After the nominations have been received the names should be circulated in a ballot paper and the date for return should be fixed two weeks after the ballot paper is sent out.

B. *Nomination of General President.*

(*a*) The General Secretary shall invite nominations for the office of General President of the Association, two years in advance, by a circular letter to the members of the Council, not later than the 15th of October. Such circular shall include a list of the General Presidents of the past 15 years and the branches of science in which they had specialized:

Nominations shall reach the General Secretary not later than the 15th of November.

(*b*) The General Secretary shall circulate the nominations received to the members of the Executive Committee for expression of opinion on or before the 30th November. Such opinions shall reach the General Secretary not later than the 15th of December.

(*c*) The nominations, together with the views of members thereon, shall be placed for decision before a meeting of the Executive Committee to be held on the day previous to the commencement of the Session of the Congress.

(Adopted the 5th January, 1937. Revised the 8th January, 1939, the 6th January, 1940, the 6th January, 1941 and the 5th January, 1942.)

INDIAN SCIENCE CONGRESS ASSOCIATION.

Twenty-ninth Session, Baroda, 1942.

Statement of Receipts and Payments of the Local Reception Committee.

RECEIPTS.	Rs.	A.	P.
Fees received from the Members of the Science Congress at the Session	1,350	0	0
Donations from Patrons, Donors and Reception Committee Members	5,960	0	0
Rent from the Exhibition Stalls, Bank Commission and Interests	96	5	0
Contribution for the Session by the Baroda Government	10,519	3	11
TOTAL ..	17,925	8	11

PAYMENTS.	Rs.	A.	P.	Rs.	A.	P.
Paid to the Indian Science Congress Association Office, Calcutta, as enrolment fees ..	....			1,350	0	0
Credited to Baroda Government as Income of Donations, etc. ..	....			6,056	5	0
Expenses for the Congress:						
Printing charges for Baroda Guide	1,036	13	2			
Charges for other printing ..	663	10	0			
Stationery	161	15	7			
Dinner	1,836	12	0			
Entertainments	272	12	3			
Volunteers' upkeep and other sundry expenses ..	626	0	9			
Conveyances	792	0	0			
Electric fittings and electric current charges	1,306	15	9			
Special fittings in buildings accommodating delegates ..	1,018	5	0			
Special requisites for fitting up the Baroda College rooms for holding the sectional meetings including fittings in the compounds	2,244	9	3			
Establishment charges and clerical expenses	559	6	2			
				10,519	3	11
TOTAL ..	....			17,925	8	11

BARODA,
Dated 12*th June*, 1942.

Sd. B. N. MEHTA,
Honorary Treasurer.

Sd. K. G. NAIK,
Sd. R. B. CHANDRACHUD;
Local Secretaries.

Proceedings of the Twenty-ninth Indian Science Congress

PART II—PRESIDENTIAL ADDRESSES

CONTENTS

Presidential Address

(Delivered on Jan. 2, 1942)

Congress President:—D. N. WADIA, M.A., B.Sc., F.G.S., F.R.G.S., F.R.A.S.B., F.N.I.

THE MAKING OF INDIA

(A Review of some Aspects of the Geological Structure of India.)

The 29th Session of the Indian Science Congress meets to-day at a centre which possesses a distinguished record as one of the pioneers of science education in India. As far back as 1882, the Baroda College was launched on its beneficent career of providing higher education to the people of North Bombay Presidency. Very soon it emerged with well-equipped departments of Physics, Biology and Agriculture, which included fully-appointed laboratories, a botanical garden, experimental farm and, later, a science museum. The vision and munificence of that Prince of many pioneering institutions, Maharaja Sayaji Rao Gaikwar, endowed Baroda with institutions for the teaching of science on a scale of liberality equalled, at that date, by few centres in India.

On behalf of the Indian Science Congress Association, I tender our sincere acknowledgments to the Government of His Highness the Gaikwar for the cordial invitation extended to the Congress last June, under circumstances that make our appreciation of His Highness's courtesy all the keener. This meeting looks forward to a pleasant and profitable week in this progressive capital of a premier State containing, as it does, many landmarks reminiscent of its early leadership in science education and of its industrial and technical developments of later date.

Indian scientists have celebrated in August last the 80th anniversary of the birthday of one who is, in every sense, their *doyen*—Sir Prafulla Chandra Ray. His has been a singular example of a life dedicated to the service of his fellow-beings, as founder of the Calcutta chemistry school, author, industrialist and public benefactor. Another remarkable octogenarian anniversary was celebrated about the same time during the year, that of Sir M. Visvesvaraya, eminent engineer and scientist whose labours during the last two decades have materially helped in building the industrial structure of India. The Science Congress, over which they presided in 1920 and 1923 respectively, is proud to claim the privilege of their continued membership.

On behalf of the delegates of the Congress I offer our felicitations to Rai Bahadur T. S. Venkatraman on the honour of Knighthood bestowed upon him by His Majesty in recognition of his meritorious researches of high scientific and economic importance.

It is my sad duty to refer to the grave loss Indian science has suffered by the untimely death of Sir Shah Mohammad Sulaiman, Judge of the Federal Court of India. A noted jurist, scientist and educationist, Sir Shah Mohammad's activities and interests were many-sided and they shed light on several spheres outside the ambit of his official duties.

SCIENCE AND THE WORLD OF TO-DAY.

The events of the last two or three decades have tended to bring science under a cloud. Its amazing achievements are at times forgotten in the wreckage of civilization that, it is feared, its misuse may bring about. What can be claimed as the finest flowering of human genius and the culmination of the heritage of Man has begun to be looked upon with growing suspicion and uneasiness. Some time ago, a group of distinguished divines in Europe pleaded for a ten-year holiday for science asking that all the laboratories and academies of science of the world may be put in cold storage for this time. The implication was that this cessation of scientific activities will mean no real loss to knowledge, but may possibly result in more worth-while knowledge: To-day, after a century of science, during which it has explored vast vistas of Nature, supervened Time and Space, conquered many plagues and diseases, probed truths about God's creation and is near making an approach to absolute Truth, science is facing the charge of helping with its inventions and discoveries man's lower instincts and lust for power, possession and aggrandizement. But for the aid of science, it is thought, his animal instincts and desires would have been infinitely less and the tempo of resulting suffering and destruction greatly reduced. But science repudiates the indictment. The ulterior end of science is search for truths of Nature and of the universe, and Truth always builds and integrates. The wreckage made possible by the abuse of science is an evanescent phase in the history of nations, and is to be compared to the havoc by earthquakes and tornadoes. Science will, without doubt, rebuild the damaged world on better foundations and reintegrate the stricken people to a new and more secure life; and the tempo of the resulting reconstruction will be no less striking.

Science pools knowledge from every quarter and offers to the man of to-day a vast accumulation of well-ascertained facts drawn from its many branches of discovery. It strives to seek absolute Truth, not utopian theories. But till the goal is reached, in the interim, in a world torn by conflicting ideas and 'isms, Truth is true only in relation to its contexts. The precision tools, the alloys, the specialized steels perfected by scientific research, can be used equally well in the making of surgical instruments, in improved ploughshares, in drills for cutting the hardest rock as well as in the making of a super-edge sword, a *messerschmitt* engine, or in the internal mechanism of a death-dealing bomb. To check this perversion of science, it is time the hierarchy of pure science asserted its patent rights on the common pool of strategic science and, backed by its $1\frac{1}{2}$ centuries of resolute strivings for the betterment of mankind, claim a determining share in the governments of the world. An international directorate of scientists, containing a due proportion of economists, engineers and industrialists, will, by adopting the technique and temper of science, govern the countries of the world better than the chancellors, diplomats and politicians who for the past 5,000 years have failed to bring harmony in human relations, but have signally succeeded in making history one record of recurrent wars.

We live to-day in a quick-changing world. Signs of a new world order are dimly apparent on the horizon. A new democracy—the democracy of science and altruistic knowledge—is emerging, pledged to do away with the 'war potential' from human society. Success may not be immediate, but there is no doubt that Man, with his centuries of struggle and conflict, is evolving. Conflict has a place in the working of the physical universe, but it is a passing phase and out of conflict comes order and evolution both in the organic and inorganic world. The poet's dream

'In the Parliament of man, the Federation of the world'—
'when war drums throb no longer and the battle flags are furl'd' is perhaps nearer realization than it ever was in the past.

Science and the changed outlook in India.

The progress of science in India is reflected in the growth of the Indian Science Congress during the last 28 years, since its inception in 1914, through the prophetic vision of the Royal Asiatic Society, Bengal, and its active foster-mothering. In the history of the Congress, we have a fit criterion of the growth of scientific spirit in India, and an index to a remarkable change of outlook from an amorphous desire for scientific progress to a definite, though still inadequate, provision for advanced science teaching, technology and research at a number of centres. In

1914–16, its membership was a few scores of Government officials, mostly of the scientific departments and surveys, with a sprinkling of university men drawn from the Province in which the meetings were held. The papers contributed numbered a couple of dozen, read at five or six sections. In 25 years, fourteen well-attended sections were meeting with a total all-India membership of, at times, over 1,000, handling in the aggregate about 700 to 800 papers, doubtless, not all of equal merit, but coming from young men versed in laboratory method of investigation, and keen on producing something original, a faculty not cultivated before and, according to some critics, foreign to Indian mind. A very welcome development of recent years is the addition of sections of Entomology, Physiology and Engineering, in each of which fruitful work has already been done, and in which the scope for productive research is still immense. The recent establishment of the Sub-Committee on Science and Social Relations by the Congress is a timely move for reviewing the progress of science in the country and appraising the extent to which it has promoted, or is capable of promoting, the real welfare of the populace. In a country whose social structure is based on traditional religion and custom it is inevitable that there should be some time-lag between the march of science and its ultimate effect on the popular welfare. This is the gap between the static India that is passing, and the dynamic India that is visualized by the scientists, but the small advances that are already visible ought to fill us with new hope and encouragement. We are awaiting the committee's report with eager interest.

The progress, though small, is, however, the more gratifying, for it is not a forced march, the outcome of a regimentation from an outside agency, but to all appearance, is the natural and spontaneous development of the Indian intellect that had lain in hybernation during five or six centuries of the dark age in India. Although it can scarcely be said that science has begun to occupy a considerable place in the general life of the masses of the people, or even the educated middle classes, one welcomes the attempts of some voluntary organizations, municipal and civic bodies through the publicity of the radio and the press, to bring the benefits of elementary science home to people at large. The infiltration of everyday science thus to the 600,000 villages, which harbour 78% of our population, is sure to bring results in improved agriculture and husbandry, health and housing, sanitation and nutrition. Here it is a pleasure to note that the advancement of higher science in India has been accelerated in the last decade by, what may fitly be called, evangelistic work of the two journals, to name them in the order of their coming—*Current Science* (1931) and *Science and Culture* (1935). These papers through the unflagging missionary efforts of their editors have already reached a high standard of scientific journalism and are filling two important needs of the country—bringing together isolated workers in the different branches of general and specialized sciences and helping to mould public mind and Governmental policies on such major issues as science education, national economic development and State aid to research. The vigorous espousal by *Science and Culture* of a policy of National Planning, creation of a Department of Scientific and Technical Research and hydro-electric development has, it seems, reached the right quarters, while the more academic bias of the editor of *Current Science* has done no less service for the spread of applied science, scientific thought and the cultural benefits of science.

But the time is not yet for a complacent self-satisfaction for science workers in India. The disproportion between the task looming ahead and the work accomplished is vast and the outstanding basic needs of national economy, such as literacy, sanitation, nutrition and improved standards of living, are reminders of our yet unliquidated liabilities. Workers in the cause of pure and applied sciences will have to multiply a hundred-fold and their efforts redoubled in order to eliminate these big debit factors from the national balance sheet.

A serious handicap to industrial progress in India was lack of planned *liaison* between industry and science. In the Board of Scientific and Industrial Research, inaugurated last year under the directorship of Sir S. S. Bhatnagar, we see the promise of a new era of planned aid to India's industry. Already the activities of the Board, through its fifteen committees, cover a wide field of research calculated to assist a variety of new manufactures. Although the services of the Board are channelized to-day to further India's war production through *ad hoc* research, with the return of peace and the withdrawal of the stimulus of war premia and priorities, there will be a greater demand on these services for domestic aid to the nascent industries it has itself sponsored, as well as to those launched by private enterprise in recent years, particularly the heavy-chemicals, engineering and metallurgical industries. The country will then need a central agency for integrating the scientific effort of the different units to-day functioning under handicaps, financial and others, and improving the defective industrial machinery of the country at present working with many emergency joints, if there is to be no setback to the hard-won industrial progress of pre-war years. This need is nowhere greater than in the mineral industries, where for the last three or four decades the raw produce of the mines, the ores and industrially vital minerals have been allowed to leave the country in ever-increasing tonnages, at ridiculously low prices, simply because of lack of technical guidance in the processing of minerals or their part manufacture before export.

The co-ordination of material science with productive industry and the marshalling of the productive resources of the country was, for long, a *lacuna* which is now being filled by the National Planning Committee, under the chairmanship of Pandit Jawaharlal Nehru. Twenty-nine sub-committees have been set up and their labours cover almost every field of the country's life and activity, cultural, productive and distributive as well as organizational.

It is a pity that this work has had almost to be cold-storaged, because of the exigencies of war. But the material already collected, and the thought bestowed upon the several aspects of national reconstruction on a comprehensive scale, cannot but prove of the utmost utility when the moment for constructive efforts arrives.

The commencement of the functioning of the Eastern Group Supply Conference at Delhi during the year is another event which the Indian Science Congress welcomes. The participants with India in this Conference—Britain, Australasia, South and East Africa, Burma, Ceylon and Malaya—have never before thought of industrial co-operation, and this step, made imperative by the exigencies of a world war, ought to augur a new era of international co-ordination in the field of commerce. When the crisis of war is over, the contacts established by this Conference should make for greater collaboration and interdependence of these nations in place of the ignoble jealousies and racial barriers that have marred international relations so far.

The Structure of India.

I have reviewed affairs and events as they affect Indian scientists. This is one part of the duty of the person called upon to preside over this assembly. I shall now present before you some investigations on the subject on which I have worked for years and on which my last three years' work in Ceylon has thrown some welcome light.

In the making of the Indian sub-continent two distinct crust-blocks of the earth's circumference, of totally different nature and constitution, have taken part. How they came to be together to build the geographic entity we call India is one of the live problems of geology. One school of geologists denies the Asiatic parentage of India. It suggests that the peninsulas of Asia have wandered far away from an ancient southern parental continent, of which Africa is the surviving nucleus, and fused along the southern edge of Asia, only during a comparatively late date in the geological history of our earth. The impact of these drifting fragments of the southern continent with the shores of Eurasia is held to have ridged up the submerged continental shelf into the imposing chain of mountains which girdle India's Asiatic front all along its West, North and East.

The impact further necessitated the underthrusting of a considerable selvage of North India beneath Turkistan and Tibet, while a still wider marginal belt has buckled under the strain of the northerly pressures into a wide and deep trough, stretching from N.-W. Punjab to the Arakan ranges. Madagascar, which undoubtedly has some consanguinity both with India and East Africa in its rock-groups and in their structural relations, is held to have started in the wake of India, but broke away from it early in the north-easterly drift. The parallel rocks and structures of Madagascar, Africa and Indo-Ceylon are cited as evidence of their pristine unity in one integral land-mass.

The orthodox school of geologists, believing in the fundamental doctrine that the present forces and agencies of the earth supply a key to the past, while admitting some undoubted merits of this theory in explaining some perplexing problems of stratigraphy and climatology, have questioned such unknown and revolutionary forces in earth-dynamics. It finds no adequate force or agency in the earth's sphere to effect a congregation of continents and their fragmentation and drifting over vast sections of the earth's circumference and is inclined to the belief in the permanence of the great ocean deeps and of the essential framework of the major continents. According to these geologists, the making of India has been an evolutionary process, the two component crust-blocks being always integral and adjacent parts, though pursuing quite distinct geographical course of events—the one a stable land-mass composed of some of the most ancient rocks of the earth and never submerged underneath the oceans; the other a flexible and comparatively weak belt of the earth's crust, for long submerged under the waters of the oceans and loaded with thousands of feet of marine sediments during this submergence. The ridging up of this sedimentary pile into the great mountain wall of India is explained as due to tangential pressures acting on this overloaded and consequently weakened zone of the crust. In contrast with the unpuckered and generally horizontally bedded rocks of the former crust-block of India, the Himalayan segment of India has undergone colossal flexuring and crumpling of strata, sheets of rock being overfolded, disrupted and thrust bodily over the severed members for miles. In these earth plications, masses of crystalline igneous rocks, granites, from the depths of the earth, have been pushed up through the sedimentary cover and now occupy the central zone of highest elevations. The sublime snow-capped peaks of the Himalayas, from Mt. Everest to Nanga Parbat, all are built of this axial granite core, which has risen five to six miles from the earth's interior breaking its way through the sedimentary crust. While the architecture of the crust lies mostly hidden beneath the surface of the rest of India, in the corrugations of the Himalayas over six miles depth of the outer lining of the earth's sphere is laid bare for the geologist's study.

The Himalayan orogeny is not an isolated unit in the mountain system of Asia, but is a part of, and stratigraphically related to, the great mountain girdle of the earth which starts from the Atlantic coast of Europe and traverses the earth along the Alps, the Caucasus, the Iranian arc, and after two or three sharp bends in its passage through India, terminates at the eastern end of the Malayan arc.

On either of the two hypothesis, the sub-continent of India consists of two crust-blocks of different nature and constitution, the rigid Archaean shield of Deccan and the 1,600 miles long folded belt of younger rocks (the Himalayas). Their interaction has produced the third physiographic division of India—the North Indian Plains—built by the alluvial deposits of rivers of the Indo-Gangetic system. These great plains of India cover a trough or depression in front of the earth-waves of the Himalayas pressing from Tibet against the immobile crust segment of the Deccan.

THE THREE STRUCTURAL UNITS.

The unravelling of the structural features of these three units of earth-body, integrated into one sub-continent, has been India's contribution to the world of science—the branches of geophysics, isostasy and geodesy deriving their earlier and more vital data from these regions from the labours, since 1860, of the pioneer workers in the departments of the Great Trigonometrical Survey and the Geological Survey of India.

As stated earlier, there is the most striking geographical antithesis between North and South India—between peninsular and the extra-peninsular India. The one is a much-folded and contorted pile of sea deposited sediments, thousands of feet in thickness; the other a non-flexible, obviously impassive block composed of ancient, crystalline rocks, which has, since the dawn of geological history, acted as a peg in the earth's crust. The latter circumstance has led to a belief in the absolute immovability or immunity of the Deccan from earth-disturbances of any kind whatever.

In the structure of India, the folded zone has played a comparatively minor part and that also during the last one or two chapters of its history, having but lately emerged from a central eurasian sea. Regionally it is in part extra-Indian and builds the lofty north frontiers, which, though they have barricaded India from the rest of Asia geographically, have knit India structurally with the Iranian ranges to the west, Tian Shan on the north and the Burma-Malay arc of mountains on the south-east. This folded zone bears evidence of great compression whereby the country between Tibet and the Ganges valley has been shortened by 60–80 miles. Only a small part of the thickening of this belt arising from the compression forms the visible mass of the Himalayas, a considerably larger part being pushed down as the roots of the mountains into the subcrustal, semi-plastic magma which acts, through its buoyancy, as the support of the Himalayas. The visible excess of mass above the surface is thus compensated underground by a displacement of the heavier and denser sub-stratum of rock (*sima*), which underlies the surface crust of the earth.

But the fold-zone of North India is of great interest in the dynamics of the earth's crust. It has profoundly modified and superseded the old trend-lines of Southern Asia. The festooning and curves of the Himalayan arc are caused by the obstructions of the rigid Indian table-land reacting against the plastic earth-folds pressing from the north and moulding their shape on its promontories and bays. Large slices of the mountains have thus slid bodily for miles over the peneplained edge of the Indian foreland, whose broad front has imposed on the mountain range its main trend-lines. The orientation of the Alai—Kuen Lun system of chains in the north, that of the Hindu Kush—Karakoram arc in the middle and of the deeply reflexed Himalayan arc in the south are broadly alike, fusing together in the Pamir vertex or knot. The Pamir is a nuclear point of Asia's mountain-system and it is in axial continuity with the Punjab wedge—the pivotal point of the Indian foreland that has guided the main Himalayan syntaxis. This Pamir-Punjab crustal wedge or knot is thus of critical importance in the orography of Asia and will take a key position in future work on orogenesis and mechanics of crustal motion in mountain-building.

The structure of the extra-peninsula is thus explained in a broad and general sense. The labours of the Geological Survey of India during the last 70 years have explored the outline of this plan and future work will add to and perfect the details. When the structure of the Himalayas is finally worked out from Kashmir to Assam, Indian geology will have made another important contribution to the world of science.

The third division of India—the Indo-Gangetic Plains—is the newest part to be added to the edifice of India and is still not complete. It has grown almost wholly within the human era by the extension of the flood-plains and deltas of the river systems belonging to the Ganges on the east and to the Indus on the west. The dust of the Himalayas, in the technical language of geology—products of erosion of the Himalayas—brought down by these rivers and their thousands of tributaries, has filled up a hollow at the foot of the Himalayas, variously computed by different authors to be from 6,000 to 15,000 feet deep. Though of great interest from human view-point as the source of great agricultural wealth, as an underground reservoir of fresh water and as the principal theatre of India's chequered history since the advent of the Aryans (when the Aryans came to India, probably this section of Aryavarta was not complete for habitation—for large parts, especially of Bengal, were still under the tidal waters of the Bay of Bengal) its importance as a geological unit is only secondary.

The southern limit of the Punjab-Bengal plains possesses a great significance in the sub-structure of India. Along this line gravimetric observations carried out by the Survey of India have revealed a sharply-marked zone of abnormally dense and heavy matter hidden under the alluvium at an unknown depth, roughly along the parallel of 23° N. Experiments with the plumb-line carried out in the middle of the plains show no deflections towards the Himalayas, as one might expect from their great visible mass, but towards a curved line underneath the plains running from Karachi towards Orissa, thus denoting some invisible excess of matter in the south counteracting the gravitative pull of the Himalayas. Similar observations carried out to the south of this line show deflections towards it, their amount gradually diminishing with distance. After repeated observations, the Survey of India has mapped out this subterranean chain of density and named it the 'hidden range'.

The South Indian highlands have not made the same appeal to geologists, mountaineers and naturalists as the snowy ranges of the Himalayas, and thus have attracted much less attention to their framework or sub-structure. Indian geologists, especially of late, however, have demurred to accept the simple view-point of the earlier workers dismissing the mountains of Deccan, South Deccan in particular, as not true mountains of uplift, but as mere relics, or residual stumps, of an old plateau left standing by the denudation of the country around, in the age-long and ceaseless waste of the land exposed to the atmosphere. Gravimetric data too suggest axes of warping and a more complicated sub-structure for these topographic prominences than is implied by mere remnants of a peneplained tableland. Professor Bailey Willis, the noted American geomorphologist, during a tour in 1936 especially devoted to this study, pointedly drew attention to the existence of definite upwarps and downwarps in Southern Deccan.

Although it is beyond doubt that the segment of India south of the Aravalli-Hazaribagh line has never been submerged, *en masse*, under the sea since the Cambrian era, or wrinkled into mountain-chains, it bears scars of several periods of earth-movements, though of a kind quite different from the mountain-building movements. Recent geological work I have been able to do in the last three years in Ceylon has greatly strengthened the new belief. The admirably lucid physiography of Ceylon, exposed in three terrace-like platforms or peneplains, of which this island is built, throws much fresh light on the origin and

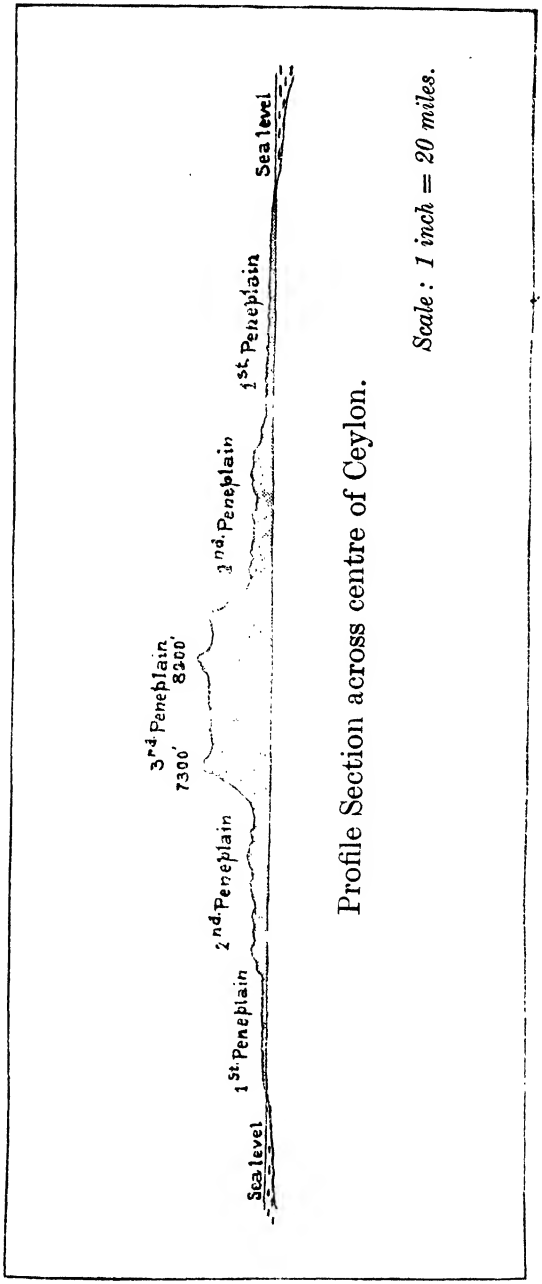

Sea level
1st. Peneplain
2nd. Peneplain
3rd. Peneplain
7300'
8200'
2nd. Peneplain
1st. Peneplain
Sea level
Profile Section across centre of Ceylon.
Scale : 1 inch = 20 miles.

FIG. 1.

constitution of the highlands of South Deccan—the Nilgiri and Palni groups of mountains. In some respects, the structure of Ceylon furnishes the key to the tectonics of South India.

Fault mountains of Ceylon and South Deccan.

Here, we may turn briefly to review the structure of Ceylon, which, though an island to-day, is an integral portion of the Carnatic gneissic terrain only recently severed from the mainland, and still connected by Adam's Bridge spanning a shallow strait, only five fathoms deep. Outside the Indo-Ceylon strait, the coastal shelf plunges to 1,000–2,000 fathoms depth.

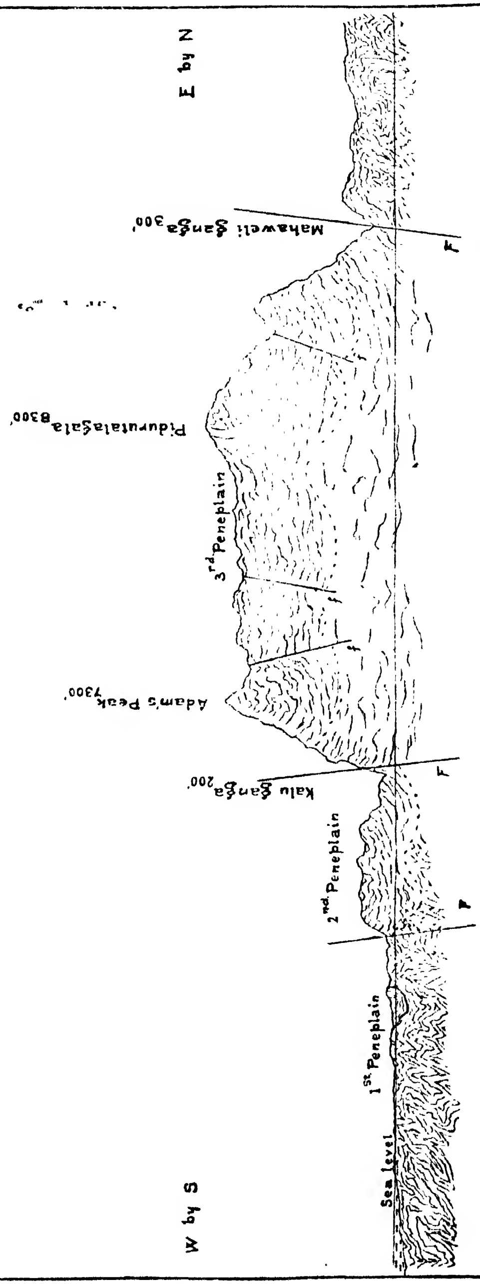
The accompanying diagrammatic section across the middle of Ceylon illustrates the profile of the country. The Ceylon rocks consist of a thick series of granulites, quartzites, crystalline limestones and sillimanite-garnet rocks (Khondalites), most probably metamorphosed sediments of Dharwar age. The extreme degree of pressure metamorphism, to which these rocks have been subjected during the orogenic revolutions of the Archaean era, is indicated by the wide prevalence and relative abundance of such small-volume minerals of condensed molecular packing as garnet, ilmenite, zircon, monazite, graphite, sillimanite, corundum (sapphire), thorianite, spinel, forsterite, pyrrhotite. The Khondalite group of rocks is thrown into a synclinorium, centrally resting on basal, finely foliated gneisses. Both the gneiss and the Khondalite group are extensively permeated by intrusions of Charnockite granites identical with the Madras Charnockites. The meteoric denudation, to which this island has been exposed since its Archaean origin, has cut the synclinorium forming the high-country and its gneissic platform, forming the lowlands, into three more or less deeply eroded terraces or peneplains rising from the sea, one above the other, in three tiers. These three terraces rise from the sea in two sharply cut steps or escarpments, the lower step about 1,000 feet above the coastal peneplain (which is very nearly a plain of marine denudation) and the second step 3,000–4,000 feet above the latter to the third and highest peneplain. Though fairly deeply dissected by branching river-valleys, the summits of the hills, ridges and other erosion remnants of all the three terraces show a general accordance of level, denoting three successive stages of base-levelling of the island. To one standing on the brim of the highest escarpment, overlooking the distant sea, the three terraces incised out of the island are as clearly apparent in the actual scene as they are in a diagram section. Now the second fact in the physiography of Ceylon which arrests attention is the number of waterfalls precipitating from these escarpments to the valleys below in single leaps of from 100 to 1,000 feet. There are no less than 20 major waterfalls, besides a large number of smaller ones. The waterfalls occur along the southern, western and eastern edge of the escarpment of the third and highest peneplain, defining a broad semicircle or crescent in the centre of the island. The significance of these vigorous young waterfalls in a land whose rocks definitely fix its age as of hoary geological antiquity (pre-Cambrian) and which should, ages ago, have attained a base-levelled topography and uniform drainage system is obvious. It suggests recent block-uplift of the Ceylon highlands, relatively to the lower ground surrounding it, through powerful dislocations or block-faults of the normal type. My field observations of these stupendous mural scarps, the lower of 800–1,200 feet, the higher of 2,000–4,000 feet altitude, have led me to the conclusion that they are not produced by ordinary denudation of dip-slopes as stated by F. D. Adams, but they are of the nature of fault-scarps, produced by nearly vertical normal faults. The rocks of the whole region are too closely and complicately folded to give rise to the long and wide dip-slopes demanded by Adam's explanation, except locally at a few spots, e.g. around Madulsima near Badulla.

The mural-scarp effect, though commonly very striking, is at some places subdued by multiple, intersecting, or step-faults; subaerial denudation also has tempered the abruptness of some of the precipices and indented them by profound gorges and canyons. In an address before a general audience, I need not enter into geographical or technical details. I have dealt with the tectonic significance of the Ceylon waterfalls in a separate paper before this Congress and the detailed geology will be published later. Here, I would emphasize the horst nature of the central Ceylon *massif*—a block of special uplift composed of crystalline Archaean rocks of 6,000 feet mean elevation, 3,000 square miles in extent, and bounded by faults on its West, South and East, but tilting sharply to its North, due to a northerly pitch of the axis of uplift.

The field geological work so far carried out in this area indicates, beyond doubt, that the Ceylon mountains are not the undenuded passive remnants left out of an old table-land, but have been 'created' by positive earth-movements, lifting them vertically in two intermittent, widely separated stages. They are what are known as 'fault mountains' in contrast to the folded, laterally compressed mountains of the Alps and Himalaya type.

The tectonic strike of Ceylon, the main grain of the country, is that of the well-defined central synclinorium, which covers three-fourths of the crystalline area of the island. If prolonged, it will continue the strike of the Khondalite basin of the Madras coast. The strike of the basal gneisses (the *fundamental gneiss* of Ceylon), though locally inconstant, is regionally consistent, and is in conformity with the north-west strike of the gneisses along the west coast of India, north of Cape Comorin.

On purely physiographic grounds, Adams made a very suggestive observation in his paper on Geology of Ceylon (1929),



Profile Section across Ceylon Island, showing the Geological Structure of the Central Massif.

Generalized Sketch Section.

FIG. 2.

that the Deccan plateau represents a continuation of the second peneplain of Ceylon and that the third peneplain of Ceylon might be found in the uplands of the Nilgiris whose highest peaks have approximately the same elevation as the culminating point of Ceylon. (Dodabetta, 8,700 feet, of the Nilgiris corresponding to Pidurutalagala, 8,300 feet, of Ceylon; the 8,000 feet peaks of the Palni escarpment correspond to 7,000 feet peaks of the great southern escarpment of Ceylon.)

To revert to the structure of South Deccan, a remarkable parallelism of many of the Ceylon phenomena is detected in the Nilgiri-Palni hills, and their southern extension, the Cardamom hills, which for hundreds of miles have their western, and still more prominently, their south-eastern sides bounded by gigantic precipices. The Nilgiri *massif* on its south-eastern face presents cliffs of 6,000 feet height rising above the peneplain of Coimbatore. Standing on the brow of Pykara precipice of 3,500 feet sheer fall, one cannot but ascribe such extraordinarily abrupt inequality of the ground in an ancient Archaean terrain to mechanical dislocation and recent block uplift. The waterfalls of this region, again, are reminders that the topography has not attained maturity, and that some recent great disruption of the river courses have taken place. The fault-scarp nature of the precipices bounding the south-east face of the Palni block of hills is no less apparent to one looking down on the plains of Madura, 4,000 feet below, from Kodaikanal. As in the Ceylon mountains, the steep scarp may not be due to single fractures, but to a system of faults, more or less vertical, in their inclination. Although modified by atmospheric wear and tear of ages they form, in many cases, most striking features of the South Indian landscapes.

That the Nilgiri and Palni escarpments are of different nature from the table-topped square-cut hills of the Deccan trap plateau is at once apparent from their difference in geological structure. In the latter, the vertical stair-like faces of the hills arise from the weathering of rectangularly jointed horizontal lava-beds, while in the former, the cliff faces, thousands of feet high, built of closely folded and contorted strata are best explained as due to mechanical disruption, followed by relative movement along the walls of the fissure. These hills are not the residual stumps of an eroded plateau, but are upraised mountains with an orographic axis, formed during a late period of earth-deformation, rejuvenating the ancient well-graded drainage-lines of the country.

THE RÔLE OF VERTICAL UPLIFT IN MOUNTAIN BUILDING.

Positive upward movements of portions of the earth's crust, formerly not recognized as an important agency in mountain-building, has now been emphasized by geophysicists. Mountains formed primarily by faults, through vertical or nearly vertical uplift, are found in many parts of the world, and have been the subject of morphological study by Blackwelder and Lauderback, notably in the Basin Range Province of North America. William Bowie, J. Barrell and other high authorities regard vertical movements of great amplitude as largely responsible for much of the visible crustal deformation. Barrell recognizes vertical movements of horsts as constituting a distinct orogenic feature and goes so far as to say that the linear mountain systems originating from geosynclinal troughs of sediments have come to be recognized as but one of several classes of mountains. He further states that the great plateau areas of folded as well as unfolded rocks have been bodily lifted one or two miles, or more, above their earlier levels. They may be broad geanticlinal arches or bounded by the walls of profound fractures.

The actual mechanism of this vertical uplift of large landmasses is to be sought in the adjustments brought about by isostasy and in the thermal expansion of the dense basaltic sub-stratum (*sima*) underlying the continents, through the effects of radioactive heating of the rocks. Joly has formulated a working hypothesis of cyclical volume changes of the sima, causing periodic earth-deformations by alternate liquefaction of the sima through accumulation of heat and its solidification through loss of that heat in long intervals of geological time.

In the absence of sedimentary formations, there are no reliable criteria for determining the age of the post-Archaean uplift of Ceylon mountains. There is, however, no doubt that there were two distinct periods of diastrophism, separated by wide intervals of time, resulting in the uplift of the two fault-bounded terraces. The lower terrace is far more worn and graded and is, therefore, clearly much older than the upper and more abruptly scarped terrace. Here the river-valleys with their numerous rapids, cascades and 1,000 feet waterfalls have a more juvenile aspect. Provisionally we may accept a late Tertiary age for the uplift of the upper terrace—an event contemporaneous with one of the two or three periods of intense diastrophic activity following the Deccan volcanic cycle, which upheaved the Himalayas and other mountains of Southern Asia. The South Deccan orogeny must be considered as coeval with these and with the last period of Ceylon's earth movements. For the date of the earlier deformation, which elevated the second peneplain, we have somewhat more exact data. The topography and drainage of this are of a more advanced type and clearly prove its relatively greater age and a small patch of Jurassic sediments containing Upper Gondwana fossil plants, near Tabbowa on the western coast—the most important documented geological record in Ceylon—helps to fix the lower limit. The complex faulting witnessed in this small Tabbowa basin, lying in the gneissic lowlands of the first peneplain, is probably a consequence of the older epeirogenic movement in Ceylon, which thus is definitely dated as post-Jurassic.

The Deccan, a much faulted land-mass.

The faults bounding the mountains of South India are only a part of the system of faults traversing the inflexible peninsular shield in many directions. Several systems of longitudinal fractures intersect this one-million-mile gneissic terrain, producing a series of sunken basins, which have acted as receptacles of the detritus of the old inland drainage. Chains of such fault-bounded depressions, filled with sediments of Gondwana age, are found along the ancestral valleys of the present Godavery, Mahanadi and Damodar rivers, which form a valuable economic asset because of the important coal-measures locked up in them. The straight and steep contours of the Malabar coast have been known since the early days of the Indian Geological Survey to be shaped by one or more dislocation; while a prominent line of fractures defines the smooth coast-line of the Makran coast of Baluchistan. The basaltic lavas of the Bombay coast, which are sub-aerially erupted flows, are known to extend down to a depth of at least 2,000 feet below the sea, indicating that the coast has faulted down to that extent since their eruption. Two more fracture plains, parallel with the Makran coast fault, remain to be noted. These have given rise to the two prominent lines of steeps in the central Indian landscapes—the Vindhya and the Satpura ranges—and at the same time guided the channels of the Narbada and the Tapti along these tectonic lines. The latter rivers are peculiar in their being the only west-flowing streams of South India, a fact which finds explanation in this accidental circumstance providing them with their valleys.

The westerly courses of the Narbada and the Tapti, in sharp contrast with the rest of the Deccan rivers flowing east-wards into the Bay of Bengal, almost from within sight of the Arabian Sea, demonstrate a singularly interesting structural feature. The easterly drainage is probably the result of an easterly tilt given to the Deccan block at the time of origin of the great Malabar coast fault, the transverse Tapti and Narbada dislocations acting as release lines. The eminent naturalist, Blanford, has dated these displacements of the western coast as Pliocene to post-Pliocene—a date which brings these momentous transformations in the figure of India within the Human Era of geological history. The former date appears to be more in conformity with physical and geological facts.

The severance of Ceylon from India took place at a somewhat earlier date, by the subsidence of south-east Carnatic under the sea. By the middle of the Pliocene, however, the connection was for the most part restored by the uplift of the

Jaffna limestone beds laid down on the Miocene sea-bed to form the dry land of North-West Ceylon.

The Indian Peninsula, thus, though still a rigid shield, is not an unbroken unit. Perhaps it is owing to this circumstance of multiple basin-faulting that it has attained equilibrium and isostatic adjustment as a whole and the remarkable immunity of this part of India from seismic disturbance is also to be credited to the absence of any tension between its several parts. Few earthquakes of any intensity have shaken the Deccan Peninsula, while those that have been recorded in extra-peninsular India form a long catalogue of tragedies.

The block-mountain and fault-basin structure of the Deccan is responsible for some highly beneficial features in the exploitation of the economic mineral resources of South India. To it we owe the uncrumpled and generally undisturbed underground disposition of the coal-seams accessible to simple mining in our coal-fields. The presence of large sheets of commercially valuable mica free from buckling and crushing and the wide stretches of richly aluminous laterite, capping the table-lands, also arise from this circumstance. The waterfalls of the peninsula—potential power-resources in coal-less provinces—are also the direct outcome of the same structural peculiarity. Large volumes of water, falling down fault-scarped highlands, provide a source of energy more lasting and economical than that obtained from a coal-field. The surface or near-surface occurrences of iron and manganese-ores, rendering these two most valuable metallic assets of the country susceptible to comparatively simple mining operations, are also indirectly ascribable to this cause.

The remaining orography of peninsular India is represented by the tectonic chains of Aravalli and the Eastern Ghats, all but worn away and now existing mainly in their roots. Once of a size comparable with the Himalayas of to-day, these mountain ranges have played a large part in the succession of geological ages and their detrital waste has furnished the raw material of the principal rock-systems of India.

The Vindhya and Satpura chains, which form the main divide of North and South India to-day, are not of as great geological antiquity. There is some evidence that in the early Eocene they were non-existent and that a north drainage flowed across their site to central Deccan. These prominent lines of steep south-facing cliffs, like the cliffs of the Western Ghats in the Konkan, have been produced, as stated before, by parallel linear faults, now usurped by the valleys of the Narbada and the Tapti. Though of tectonic origin, these ranges have no axis of folding or compression.

The mountains of the Assam ranges and those of the Salt Range in North-Western Punjab are two unique and rather aberrant structural features of India. Though so near to the

Himalayas, their orography is unrelated and independent and their folds, faults and thrust structures present problems that have aroused the keenest interest of geological workers in India.

THE VOLCANIC PLATEAU OF NORTH DECCAN.

A large section of the Deccan, so far left out of the above description, now claims attention, portions of Bombay-Deccan extending from Kathiawar to Nagpur, and from Malwa to Dharwar. This part of India possesses the simplest geological structure possible, for these 200,000 miles tract is built up of flat-reposing sheets of lava, forming a pile from 2,000 to 6,000 feet high, completely burying the ancient geography of the land. Time has sculptured this lava plateau into imposing hills, valleys and plains, but these high hills are only the few outstanding portions of the plateau that have withstood weathering, and have no pretensions to be classed as mountains of elevations. They have no orographic axes of folding, but have remained in their original position and attitude. At the time of its completion, this volcanic formation, known as the Deccan trap, must have covered a much wider extent both in area and altitude, and it will not be far wide of the mark to say that 400,000 cubic miles of molten rock was poured out from the bowels of the earth during this volcanic period—a volume of rock exceeding both in bulk and mass that represented by the entire body of the Himalayas, and of an average density one-tenth higher than that of the Himalayan rocks. The transfer of so much heavy matter from the interior of the earth to the exterior must have had reactions on the isostatic adjustments of the neighbouring sections of the crust. Relief would be sought in the downwarp of large tracts whereby the relatively lighter rocks of the upper crust would be depressed and condensed. We might see in this a predisposing cause for the sinking of the long and wide tract of the Indo-Gangetic plains to a depth of some thousands of feet in front of the Himalayas. The completion of the gigantic volcanic discharge of the Deccan trap may be considered as pene-contemporaneous with the first uplift of the Himalayas in Mid-Eocene to Post-Eocene time. No satisfactory theoretical explanation has yet been found for the hidden chain of dense matter detected by gravimetric survey, referred to before on page 9, under the southern edge of the plains. A suggestion may be advanced that the upwelling of the basaltic magma forced up, along the north periphery of the Deccan trap reservoir, masses of ultra-basic, dunitic rocks from the deeper levels of the reservoir to a position in the upper crust near enough to affect the plumb-line and the pendulum. A concentration of masses of heavy rock along this chain was suggested as long ago as 1914 by Sir Thomas Holland as a matter needing further attention of geologists and geodesists.

The parallelism of the hidden range with the Himalayan protaxis cannot be entirely accidental and may have a structural significance suggesting sub-crustal redistribution of heavy and light rocks—an upwarp of the sima preceded, or caused by, the downwarp of the Gangetic tract.

THE SCULPTURE OF TIME.

But in the making of India the constructive geological processes that we have hitherto considered have only given the broad outlines of the country; the shape or figure of India, as we see it to-day, is determined essentially by the destructive processes of Nature. The sea, rain, rivers and other atmospheric agencies of change, by their ceaseless action have cut deep into the profile of India and have removed thousands of feet of matter from off the surface, producing the existing sculpture of the land. The 6,000 to 15,000 feet thick beds of clay, sand and silt, laid down in the Indo-Gangetic plains, are all derived from the decay of the Himalayas. They are only a small measure of the waste of these mountains. The dissection of the originally two miles high volcanic plateau of Malwa-Deccan to the depth of over a mile into the picturesque alternation of plains, valleys and hills is another visual demonstration of the power of surface natural agencies in shaping the surface features of the continents, while constantly lowering their level to the mean sea-level. These base-levelling processes have in the past, repeatedly peneplained vast tracts of India, but the geological cycle was not allowed to be completed by the supervening earth movements which restored topographic youth. Rajputana and Madras have thus been levelled and peneplained and rejuvenated by timely earth-movements reversing the geological cycle time and again.

Ladies and Gentlemen, the above is manifestly an incomplete summary of the structure of India. It has dwelt mainly on those aspects which have received some additional facts from the work on which I have been lately engaged. I have refrained from giving a review on recent work in the geological sciences done in India, as this account was presented before the Congress in a long paper, published so late as in 1938, at its Jubilee Session held at Calcutta.

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SECTION OF MATHEMATICS AND STATISTICS

President:—P. C. Mahalanobis

Presidential Address

(*Delivered on Jan. 4, 1942*)

SAMPLE SURVEYS

I offer my thanks to the authorities of the Indian Science Congress for electing me to be the president of the section of Mathematics and Statistics. For a long time there was one single section for Mathematics and Physics. In 1940 at Madras this section was divided into a section for Physics and a separate section for Mathematics, and at Benares in 1941 Statistics was added to the section of Mathematics. This year for the first time a person who, although not a statistician by profession, has his chief interest in statistical work has been asked to preside over the new section. I accept this honour not in my individual capacity but as an humble representative of statistical science.

1. Mathematics, Physics and Statistics

The subject of statistics has two different aspects. On one side statistics consist of facts collected for administrative purposes or State-craft in its widest sense. On the other hand, statistical methods constitute the science of counting and taking measurements and interpreting the results. In this section we are concerned mainly with this second aspect. It is not inappropriate that analytic statistics should be associated with mathematics and retrospectively also with physics for the history of statistics has been intimately connected with both subjects. The theory of probability supplies the foundation of statistical science; and traditionally probability has been always cultivated as a branch of mathematics. The very foundations of the subject have been laid by mathematicians like Fermat, Pascal, the Bernoullis, De Moivre, Laplace, Legendre, Gauss, Poisson, Fourier, Cauchy, Tchebycheff and others.

In spite of this long association I am doubtful, however, whether statistics can be properly considered to be a branch of pure mathematics. Bertrand Russell described mathematics as all statements which can be expressed in the following form:

If P, then Q

with the important condition that it must be entirely immaterial what P and Q are. All results in pure mathematics thus follow by inexorable necessity from the given premises. This is why mathematics is essentially a form of logical determinism. In its own sphere it is absolute, it is perfect, and the very possibility of doubt and error is excluded.

When we come to probability or statistical theory the position is, however, entirely different. The certainty of '*if P, then Q*' has vanished. On the other hand, we find that if P is given then there is not one single Q, but a plurality of Q's all of which may occur. The concept of probability itself involves a multitude of possibilities.

Not only this; all statistical or probabilistic statements must be necessarily uncertain. Every prediction has to be made in terms of assigned odds or, in more technical language, at some given level of significance. That is, statistical statements can only be made in the form:

> *If P, then Q will follow* 9 *times out of* 10 *or* 99 *times out of* 100, *or* 999 *times out of* 1,000 *trials, and so on.*

However large the odds may be, some margin must be left for the failure of the prediction. If the statement is statistically valid then in the long run the prediction must fail to the extent of this permitted margin. If we are working with the five per cent level of significance then the prediction must fail, in the long run, on five per cent of occasions. If we are working with the one per cent level of significance then the prediction must fail, again in the long run, on one per cent of occasions, and so on. If the prediction does not fail to the assigned extent then the statistical reasoning is not valid. In other words, statistical results in order to be right must be sometimes wrong. This paradox is inherent in the very nature of probability and statistics. But this lack of consistency is intolerable in pure mathematics.

This distinction between pure mathematics and statistics is important, and represents the difference between the divergent methods of deductive and inductive logic. We may clearly see its repercussions in the history of physics. The spectacular development of classical mechanics in the seventeenth and eighteenth centuries gave an overwhelming bias to physical science in the direction of materialistic determinism. From the detailed knowledge of a system at one single instant it should be possible, according to classical physics, to predict the whole future history of the system. A complete solution, however, could be worked out only in the case of two particles; the problem of three bodies remained partly unsolved.

For studying more complicated systems consisting of many particles or phases it gradually became necessary to introduce statistical concepts in connexion with the second law of thermodynamics in the middle of the nineteenth century. A little earlier the classical theory of errors had been developed for the reduction of physical measurements. The normal (Gauss-Laplacian) curve of errors used here with success served as a model for the Maxwellian distribution of velocities in the kinetic theory of gases. Statistical mechanics was then gradually built up on probabilistic foundations by Boltzmann, Gibbs and others so that by the end of the nineteenth century statistical physics had become an integral part of science.

In the opening years of the twentieth century a more profound change took place with the advent of the quantum theory and the principle of relativity. Gradually the whole scheme of Newtonian mechanics, the classical theory of electromagnetism, the all-pervading ether (which at one time had been looked upon as the greatest achievement of nineteenth century physics), and the principle of conservation of mass and energy were abandoned. Finally, materialistic determinism was replaced by the well-known principle of uncertainty.

The Principle of Uncertainty

This principle is usually expressed by the Heisenberg inequality in the form:

$$\Delta p \cdot \Delta q \geqq h \quad \ldots \quad \ldots \quad (1)$$

in which p and q represent the generalized momentum and space co-ordinates, and h is Planck's constant. This inequality is suggestive from the statistical point of view. First of all it explicitly denies the possibility of either Δp or Δq assuming an infinitesimal value. In other words, the uncertainty principle definitely asserts the discrete and finite nature of physical changes. This is why in modern physics infinite extension, or infinite velocity, or infinite number of particles have to be replaced by large but finite quantities. The elegant and perfect methods of pure mathematics based on the concepts of infinitesimals and continuity cease to have rigorous application, and recourse must be had to statistical methods.[1]

Secondly, the Heisenberg relation shows a certain formal analogy with the correlational expression in a limiting form.

[1] The definition of probability is simple and clear so long as it is based on the ratio of finite frequencies. The passage to continuous probability involving infinite aggregates presents many difficulties which I am not sure have been wholly overcome. This, however, does not stand in the way of infinitesimal calculus or similar tools of pure mathematics being used for calculations in probability or statistics in the same way as such tools are used in physics in spite of the admittedly discrete structure of matter.

Thus if Δx and Δy are two statistical deviations which are measured from mean values in terms of respective standard deviations and ρ is the coefficient of correlation then we know that

$$E(\Delta x \,.\, \Delta y) = \rho \qquad .. \qquad .. \qquad (2)$$

where E stands for the expectation value. In case this relation is valid for each individual pair of Δx and Δy we may drop the symbol E, and if ρ is a *minimum* value we may introduce the sign of inequality and write

$$\Delta x \,.\, \Delta y \geqq \rho \qquad .. \qquad .. \qquad (3)$$

Comparing (1) and (3) the formal interpretation of the uncertainty principle would appear to be the explicit denial of the independence of Δp and Δq, and the postulation of the existence of a 'correlation' between these two entities of which the minimum value is h. I am inclined to think that this irreducible 'correlation' again indicates another aspect of the finite or bounded structure of the world of physics which finds a different expression in cosmological constants.

Be this as it may, the transition from mechanistic determinism was completed by the advent of the principle of uncertainty; and the whole foundation of physical science became entirely statistical in nature. The contrast between the old and the new view of things has important theoretical and practical consequences. Classical physics was founded on causal laws and mechanistic determinism. The aim was to proceed by mathematical methods from general or universal laws to particular results.

The Statistical Method of Sampling

In statistics, on the other hand, we frankly take our stand on sampling theory. The typical method is to proceed from the sample to the population, that is, from the particular to the general. The possibility or rather the certainty of error is inherent in the very structure of statistical reasoning.

In the place of inexorable causal laws statistical results are governed entirely by the laws of chance. The main drive of experimental procedure is therefore to secure a random sample without any bias. This process of randomization guarantees the validity of the estimate of error. The theory of sampling distributions in terms only of actual observations (usually called distributions in the Studentized form[1]) achieves something more. It makes possible general conclusions being drawn with logical rigour from particular observations. This is why R. A. Fisher has claimed that statistics supplies the only logical foundation for scientific inference.

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[1] From the pioneer work of W. S. Gosset writing under the pseudonym 'Student'.

Another characteristic contrast in experimental procedure is worth noting. The orthodox principle is to isolate and study each factor of variation by itself. This, however, is possible only in the case of extremely simple physical systems, and even then only approximately as the uncertainty principle tells us. When we come to the biological, economic or social sciences, isolating individual factors is even conceptually impossible as the inter-connexions between the different factors are an integral part of reality. In this situation we have to study the factors not in isolation but in their inter-related pattern, or to give up the study altogether. This is where statistical methods become indispensable. The difference between old and new methods has been described by R. A. Fisher in picturesque language: 'No aphorism is more frequently repeated than that we must ask nature a few questions, or ideally one question at a time. This view is wholly mistaken. Nature will best respond to a logical and carefully thought out questionnaire; indeed, if we ask her a single question, she will often refuse to answer until some other topic is answered.' [1]

This, however, is not all. There are other reasons why the statistical method is growing in importance every day. If we want to purchase a large quantity of, say, rice, or bricks, or coal or electric fuses or any other commodity, we usually make our choice by testing small portions or samples out of the articles offered to us. In the case of rice or bricks it is theoretically possible to examine each single grain or each single piece of brick if we so desire and can afford to devote to the task the required time and energy. But in the case of coal or electric fuses it is not even conceptually possible to make a complete test by burning the whole consignment before we purchase it. There is no other alternative but to have recourse to the method of sampling.

Not merely in purchasing material in the bulk but in testing the quality of manufactured articles inspection by sampling is indispensable in practice. A hundred per cent inspection is prohibitive not only because of its excessive cost but also because the time factor is often decisive, for example, in stepping up production under war conditions.

In agriculture, public health, or social and economic studies statistical methods are being increasingly used. It is scarcely necessary to multiply examples. In practically all situations in which we have to work on a large scale, estimates have to be made almost invariably by the method of sampling. The larger the scale of work the greater is the advantage of the sampling method. With the growing complexity of human society, scales of operation are rapidly increasing in size. And this is why the sampling method is also daily growing in importance.

[1] *Jour. Min. Agri.*, **33**, 503.

Statistical Engineering

In application to practical problems the sampling method thus has to be used often on a very extensive scale. The task then partakes something of the nature of an engineering project. This is not peculiar to statistical science. The same tendency may be seen in physics. The construction of a two-hundred-inch telescope or a cyclotron is essentially an engineering undertaking.

In the same way in statistics, especially in sample surveys, we are entering this engineering phase. The underlying principle is often simple and familiar. The real task is to give it practical shape. Firstly, to attain results of real importance; and secondly, to do this at a cost which will be reasonable for the practical advantages secured. This is of course quite familiar in physical or chemical engineering. Technical processes are sometimes successful on a laboratory scale, but are not capable of being used in practice, either because of the difficulties of doing the work on a sufficiently large scale or because of the prohibitive cost.

Sample surveys also must be made to work on a large scale under actual field conditions. This requires not only statistical theory but organizational skill in handling human material, and the ability to circumvent physical obstacles. Team work is particularly important. And this is why mathematics, physics, engineering, and administrative work all have their place in statistical science.

I now propose giving a general account of the sample census of the area under jute in Bengal on which we have been working for about four years. This will give a concrete idea of the problems which arise in such surveys.

2. A Sample Survey of the Acreage under Jute in Bengal

Jute forms one of the two most important individual items in the export account of India. On an average eighty-five per cent of the total production is grown in Bengal. Estimates prepared by the Bengal Agriculture Department were known to be unreliable: and in 1934 the official Bengal Jute Enquiry Committee noted that 'the estimates furnished were usually mere guesses which were always conservative and in most cases far from truth'. In view of the importance of the question the Indian Central Jute Committee, immediately after its formation in 1937, sanctioned five lakhs of rupees[1] spread over five years for the improvement of the jute forecast.

[1] That is, £37,500 in five years or £7,500 per year on an average.

Sample Survey versus *Complete Census*

During the ten years, 1929–1938, the average area under jute in Bengal was roughly of the order of two and a quarter million acres, or about 3,500 square miles. A rough calculation shows that in an ordinary year more than one crore [1] of plots sown with jute are scattered among eleven or twelve crores of plots of all kinds. One way of estimating the total area sown with jute in any particular year in Bengal would be to search out one crore or more of these individual plots under jute. This would require a large army of five or six thousand investigators and would cost something like ten or twelve lakhs of rupees.

Let us now see how the sample survey can help in this matter. In this plan the whole province would be divided into a suitable number of zones. Within each zone a suitable number of points would be then selected strictly at random; and at each of these points a sample-unit of a suitable size would be surveyed in detail. In this way it would be possible to determine the proportion under jute in each sample-unit, and hence the average proportion within each zone. Multiplying by the total area of each zone it would be then possible to estimate the area under jute in each zone; and then, by subsequent tabulation, the total area under jute in each district or in the whole province.

The basic idea is simple and familiar. The work, however, has to be carried out over a large area of the order of 50 or 60 thousand square miles, and will require a good deal of expenditure. Economic planning is therefore of paramount importance. In this situation three questions immediately arise:

(*a*) What should be the size of each sample-unit? Should these be very small of the order of a fraction of an acre, or comparatively small like 3 or 4 acres, or moderately large like 40 or 50 acres, or very large comprising several hundreds of acre in area?

(*b*) Secondly, how many of such sample-units should we use?

(*c*) And finally, what is the best way of distributing these sample-units among different districts, regions or zones?

Naturally these questions have to be settled in accordance with (1) the degree of precision required in the final estimate; and secondly, (2) the amount of time or money at our disposal. If the total amount of time or money is fixed, our aim will be to design the sample survey in such a way as to give the final result with the smallest possible margin of error. On the other hand, if the level of precision to be attained in the final estimate is assigned, our task will be to prepare the design in such a way as to reduce the cost of the survey to a minimum.

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[1] One crore = ten million.

The precision as well as the cost of the survey will of course depend on the size (i.e. area) of individual sample-units and their total number. If we increase the size of each individual sample-unit we shall be able to decrease the margin of error or the variance of individual units. This will, however, increase the cost. On the other hand, if we keep the total expenditure the same, any increase in the size of individual sample-units will naturally decrease the total number of units which we can afford to have. This reduction in the total number will necessarily reduce the precision of the mean value of the final estimate. Whether there is any net gain or not will depend on just how the variance of individual sample-units decreases with increasing size.

This is not all. The question of location of the sample-units is also of importance. If we have a large number of sample-units, the distance between neighbouring units will be small; and the time spent in moving from one sample-unit to another will also be small. On the other hand, if we have a comparatively small number of sample-units, these will be more scattered; and hence more time will be required for journeys between different sample-units. In fact, in large-scale sample surveys, the time required for journeys is as important as the time spent in actual enumeration work. This is why both precision and cost will depend not only on the size of individual sample-units but also on their total number and the manner in which they are distributed over the whole area.[1]

This so far as the sampling technique is concerned. We would also require a staff of several hundreds of investigators and inspectors for the field enumeration, and computers for the statistical portion of the work. From the beginning we clearly realized the need of (*a*) developing an efficient sampling technique on one hand; and on the other hand, (*b*) building up a suitable human agency to carry out the survey. In 1937, however, we did not have any idea regarding the best size or number of sample-units or the cost of operations, nor did we have any trained staff for carrying out the work.

Earlier Stages of the Work: 1937–1940

In this situation taking up the work on an extensive scale would be sheer waste of time and money. My idea was to start with a small-scale experiment for collecting information, however rough, about the basic factors of variation and cost of operations; and to expand the work gradually in the light of the experience gained during the earlier phases. This would

[1] A fuller theoretical discussion is given in *Sankhyā*, Vol. 4, Part 4, pp. 511–531.

require time, and I pointed out the need of going slow in the beginning. I encountered a good deal of opposition, but ultimately had my way.

We started in 1937 with a complete enumeration of only 124 square miles and a sample survey with units of size 5 acres. We spent less than seven thousand rupees on the field work, and yet this gave us most valuable information regarding the cost of operations and the possibilities of the sample survey. In 1938 we started a systematic study of both variance and cost functions, and spent about eighteen thousand rupees on the field survey covering 414 square miles. The work done proved conclusively that the sample survey could be used with success in actual practice. In 1939 the field work was further expanded to cover 2,553 square miles at a total expenditure of Rs.49,000. It now became clear that for general use 4 acres could be a convenient size, but sample-units varying in size from 2 to 8 acres would also be useful. This completed the first phase of the work. In 1940 we carried out a trial survey on a large scale in eight important jute districts covering 20,553 square miles at a cost of about sixty thousand rupees for the field work alone.

Provincial Sample Census in 1941

Finally, in 1941 we carried out, for the first time, a full-scale provincial survey covering an area of 59,199 square miles. We used sample-units of size varying from 1 acre to 9 acres, nearly half the number being of size 3 or 4 acres; the density varied from 0·22 to 3·30 per square mile for the full sample. The geographical unit was the *thana* or police circle with an average area of 110 square miles. For purposes of zoning these were grouped into ten classes according to the intensity of cultivation, and were allotted the appropriate number of sample-units of the required size.

The field work was arranged in the form of two independent but inter-penetrating half-samples. Linked pairs of sample-units were located at random on maps in the form of dumb-bell shaped figures one end of which represented the sample-unit belonging to half-sample (A) and the other end represented the sample-unit belonging to half-sample (B). The information for all sample-units belonging to half-sample (A) was collected by one set of investigators while the information for the sample-units belonging to half-sample (B) was collected independently by an entirely different set of investigators. The time programme was arranged in such a way that investigators belonging to the two different sets (A) and (B) never worked in the same region at the same time. In this way we obtained independent records for each of a pair of adjoining sample-units, and two independent estimates of the area sown with jute.

The survey was carried out over an area of nearly 60,000 square miles and required a staff of about 500 men. This in itself is not a large number, and had they been working in a compact group it would have been an easy matter to supervise their work. In actual fact these men were, however, scattered over the whole province. Careful preparations had to be made to keep contact with the field investigators, to arrange for the inspection of the primary work, to ensure that the field records were promptly despatched to headquarters, and so on. In spite of these difficulties the agreement between the two half-samples was quite satisfactory.

Precision of the Final Estimate

Various tests were used for this purpose of which I may describe one. Differences between the estimates for each pair of sample-units (A) and (B) were used for calculating values of Student's *t*-statistic[1] separately for each *thana* (police circle). The corresponding probability of occurrence was obtained in the usual way. There were 109 cases out of 379 in which the probability was less than five per cent. The expected number of values significant at the five per cent level is about 19. There was, therefore, an excess of no less than 90 cases in which the agreement between two half-samples was not satisfactory.

A detailed examination of the field records showed, however, that in many cases the disagreement could be traced to real differences in weather or other physical conditions. For example, in many *thanas* the first half-sample was collected when weather was still dry and sowings had not started properly, while the second half-sample was collected after heavy showers. In such cases, owing to heavy sowings, the second enumeration was bound to give much higher proportions of land under jute. It was possible in this way to explain at least 84 cases of discrepant *t*-values. Omitting these 84 cases and 12 other cases with 1 and 2 degrees of freedom the actual position is shown in Table (A) in which col. (1) gives the range of probability of occurrence; cols. (2) and (3) the observed and expected number of *t*-values; col. (4) the difference between observed and expected values; and finally, col. (5) the corresponding values of Chi-square.

The number of cases in which the probability exceeds 0·95 is only 3 against an expected number of 15. This shows that there were no cases of suspiciously close agreement between the two sets of results. The half-sample method was thus entirely successful in ensuring the two estimates being really independent.

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[1] Bartlett's $\sin^{-1}\sqrt{p}$ transformation cannot be used here for obvious reasons. But as degrees of freedom are fairly large, especially in thick zones, mean values may be expected to behave in a more or less 'normal' manner.

TABLE (A). *Comparison of Half-samples (A) and (B): Student's t-statistics for Police Stations*

Range of P(t): probability of occurrence of t-values	Number of cases		Difference between observed and expected	Chi-square
	Observed	Expected		
(1)	(2)	(3)	(4)	(5)
Less than ·01	11	2·95	+8·05	21·96
·01– ·05	14	11·80	+2·20	0·87
·05– ·10	20	14·75	+5·25	1·87
·10– ·90	235	236·00	−1·00	0·00
·90– ·95	12	14·75	−2·75	0·51
·95–1·00	3	14·75	−11·75	9·36
TOTAL ..	295	295·00	0·00	34·57

We also find that in about eight *thanas* (with $p<0{\cdot}01$) the agreement between the two half-samples was not satisfactory. Full statistical control was thus not established at the most in eight or three per cent of the *thanas*. Considering the difficulties of carrying out a sample survey on such a large scale it is not unsatisfactory to find that there was good agreement between the two half-samples in at least ninety-seven per cent of the *thanas*.

It will not serve any useful purpose to give here details of the estimates. I may mention, however, that according to the sample census the total area sown with jute in Bengal in 1941 was 1,576,000±17,000 acres. The estimated probable error is thus only about 1·1 per cent.[1] Under the Jute Regulation Scheme permission was given to sow jute over 1,623,000 acres, but the mere fact that a license was issued in respect of any particular holding does not necessarily mean that the land was sown with jute. In fact, owing to adverse weather conditions and other reasons, one would expect that the actual area under jute would be lower[2] than the area for which licenses were originally issued. The difference between the license figure and the sample estimate is, therefore, in the right direction. This was corroborated at a later stage when a detailed checking of the area sown with jute was carried out under the Jute Regulation Scheme and the area actually sown with jute was found to

[1] This value of the probable error is itself an approximate estimate based on certain assumptions.

[2] Exceeding the licensed figure is unlikely as it is punishable with a heavy fine under the Jute Regulation Act.

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be 1,532,855 acres.[1] This gives us an entirely independent and objective check on the accuracy of the sample census.

We find then that the internal precision (as measured by the probable error) as well as the objective accuracy (based on comparison with the Jute Regulation figures) was high and the margin of error was well within the limit of five per cent set by the Jute Census Committee.

The present survey thus conclusively demonstrates the great possibilities of a random sample survey for estimating crop acreage. In 1941 we had spent Rs.1,40,000; but excluding certain expenses of a non-recurring nature it is expected that a similar survey can be carried out from year to year at a cost of a little over one lakh of rupees. A complete enumeration with checking would probably cost something like fifteen lakhs of rupees. By using an efficient sampling technique, it is thus possible to get an estimate with a margin of error of the order of one or two per cent at a cost of only one-fifteenth of the cost of a complete enumeration.

3. The Design of Sample Surveys

Proper designing is as important in sample surveys as in agricultural and other experiments. The fundamental aim is the same in both cases, namely, to collect the largest possible amount of information with the least possible expenditure of time and money. But the approach and the type of the design is naturally different in the two cases. In large-scale sample surveys the work of planning broadly falls into two stages, namely, the exploratory and the final. The aim of the exploratory stage is to collect basic information required for preparing the final plan. For purposes of illustration it will be convenient therefore if I first describe the final stage of the work in the Jute Census Scheme.

The Basic Cost-Variance Table

I have already explained that in large-scale surveys the time spent in journeys from one sample-unit to another is usually as important as the time spent in actual enumeration work. I have also mentioned that throughout our work on jute and paddy in Bengal we found that the decrease in variance was appreciably less than what one would expect in the case of a truly binomial or normal variate. This being so, the precision as well as the cost of the survey will depend on both the size (area) and the density (or number per square mile) of individual

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[1] Published on 2nd April, 1942, in the *Indian Trade Journal*, Vol. CXLV, No. 1867, p. 32. The difference between the sample census estimate and the registration figure is thus about 43,000 ± 17,000 acres.

sample-units. It is necessary therefore to construct what may be called the 'basic cost-variance table' appropriate for the survey. I am showing below a typical example from our work in the Jute Census Scheme.

In Table (B) col. (1) gives the expenditure in rupees and annas per square mile ranging from 8 annas to Rs.2-8-0 per square mile. This range is naturally fixed by what may be broadly called budget considerations. The best size in acre (x) and the best density in number per square mile (y) of individual sample-units is shown in cols. (2) and (3). The best size decreases while

TABLE (B). *Basic Cost-Variance Table*

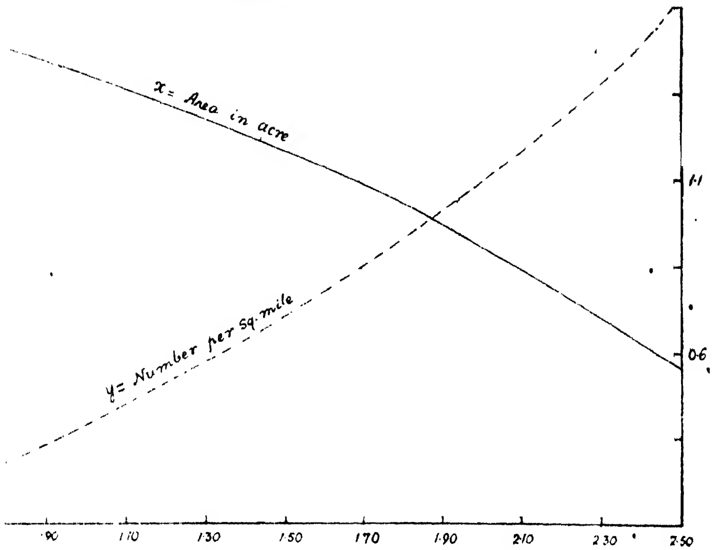
Cost in rupees per sq. mile (ϕ)	Individual sample unit		Relative variance θ $= 100\, v/pq$	Relative cost per unit of information ($\theta . \phi$)	Differences	
	x=Area in acre	y=Number per sq. mile			$\Delta\theta$	$\Delta(\theta\phi)$
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rs. A. P.						
0 8 0	6·55	0·140	140	70	−66	−14
0 12 0	6·22	0·257	74	56	−24	− 6
1 0 0	5·82	0·388	50	50	−14	− 5
1 4 0	5·42	0·537	36	54	− 9	− 5
1 8 0	5·95	0·707	27	40	− 5	− 2
1 12 0	4·45	0·885	22	38	− 4	− 2
2 0 0	3·80	1·118	18	36	− 3	− 2
2 4 0	3·15	1·345	15	34	− 2	− 2
2 8 0	2·44	1·615	13	32		

the density increases with increased rate of expenditure per square mile. This simply means that if we work with a small number of sample-units it is profitable to make the size of each sample-unit comparatively large. On the other hand, if we have a high density or a large number then it is better to work with sample-units of a comparatively small size. This comes out clearly in Chart 1.

Within the range of practical interest the most economical size of sample-units lies roughly between 2 and 7 acres. The best density for each half-sample varies from roughly one sample-unit in 7 square miles to 1·5 or three sample-units in 2 square miles. It may be noted that the variation in density is more important than the variation in size in the area census.

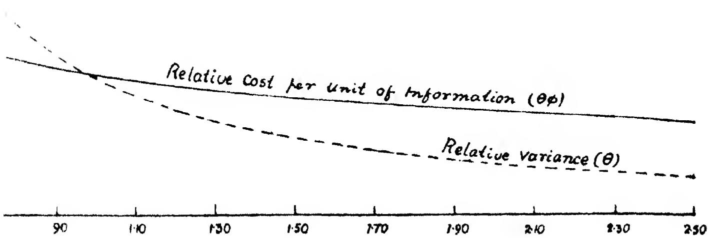
Let us now consider the precision of the result. The relative variance θ (which means the variance expressed as a fraction of the normal variance multiplied by a constant for

CHART 1. *Size and Density Curves*



ϕ = Cost in rupees per sq. mile →

CHART 2. *Cost-Variance Curves*



ϕ = Cost in rupees per sq. mile →

convenience of calculation) is shown in col. (4). This naturally decreases with increasing expenditure. From the point of view of statistical theory the same thing can be expressed more conveniently in the form of the relative cost per unit information (where 'information' stands for the reciprocal of the variance in accordance with the definition given by R. A. Fisher). This is shown in col. (5), and in Chart 2.

If we consider the relative variance shown in col. (4), it will be noticed that in the beginning it decreases rapidly with increasing expenditure, but the rate of decrease gradually falls off. This is more clearly brought out in col. (6) which gives the rate of decrease in variance. The precision of the final estimate naturally increases with expenditure, but the rate of increase steadily falls off. This is simply an instance of the law of diminishing returns.

Let us now see how we may use the 'basic cost-variance table' for the design of large-scale sample surveys. If the intensity of cultivation (the proportion of land under jute) is the same everywhere then this basic table can be used directly. For example, if the total budget (or what comes to the same thing, the rate of expenditure per square mile) is fixed, then all we have to do is to make our entry in Table (B) in col. (1), pick up the appropriate values of the best size (x) and density (y) of sample-units from cols. (2) and (3), and obtain the corresponding variance or precision of the final estimate from col. (4). We may also get the appropriate values of (x) and (y) directly from Chart 1 and of the relative variance from Chart 2 corresponding to any assigned value of cost per square mile. On the other hand, if the precision or variance of the final estimate is assigned, we then make our entry in col. (4), pick up the appropriate optimum size and density of sample-units in cols. (2) and (3), and find the rate of expenditure from col. (1). In this case using Chart 2 we first obtain the cost per square mile corresponding to the assigned relative variance, and then using Chart 1 get the appropriate values of size (x) and density (y) of sample-units.

In actual practice the intensity of cultivation itself varies widely from one region to another. In this situation some further calculations are necessary. The principle, however, is easy to understand. We divide the whole area into a suitable number of abstract zones in terms of intensity of cultivation (i.e. the proportion of land under jute). As each of these zones may be considered to be more or less homogeneous it is possible to use the basic Table (B) for each zone separately. We have then to fix the size and density of sample-units and hence the rate of expenditure in each zone in such a way as to get the highest precision in the final results. This involves certain summation terms and the use of undetermined multipliers in the numerical calculations. This is laborious but straightforward and need not detain us here. The point to be emphasized

Successive Stages of the Jute Census Scheme

Table (C/1). *Volume of Work and Expenditure*

Jute seasons (year)	Area in sq. miles	Number of sample-units	Number of field staff	Expenditure in rupees: Field branch	Statistical branch	Over-head and non-recurring	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Rs.	Rs.	Rs.	Rs.
1937	124	1,488	35	6,700	10,000	100	16,800
1938	414	7,888	110	18,200	16,500	3,100	37,800
1939	2,563	12,000	129	47,300	36,400	6,800	90,500
1940	20,533	41,345	272	59,600	35,600	21,700	1,16,900
1941	59,199	57,362	514	79,800	46,500	26,000	1,52,300
Total	..	..	..	2,11,600	1,45,000	57,700	4,14,300

Table (C/2). *Rates of Expenditure per man-month*

Jute seasons (year)	Volume of work in man-months: Field	Statistical	Total	Rate in rupees per man-month: Field	Statistical
(1)	(2)	(3)	(4)	(5)	(6)
1937	64	102	161	104·69	98·04
1938	212	183	395	85·85	90·16
1939	531	378	909	89·08	96·30
1940	638	396	1,034	93·42	89·90
1941	941	470	1,411	84·80	98·94

Table (C/3). *Rate of Expenditure per square mile*

Jute seasons (year)	Expenditure in rupees per sq. mile: Field	Statistical	Total	Man-months per 1,000 sq. mile: Field	Statistical
(1)	(2)	(3)	(4)	(5)	(6)
1937	54·03	80·65	135·48	516	823
1938	43·96	39·86	91·30	512	442
1939	18·45	14·20	35·31	207	147
1940	2·90	1·73	5·69	31	19
1941	1·35	0·79	2·57	16	8

It will be seen that a succession of gradually expanding surveys has many advantages. In this method the design of the survey at each stage, except of course the first, is based on actual experience and objective study of relevant factors of variation. It gives complete control over the expenditure and enables planning on economical lines. Finally, the gradual expansion of the work makes it possible to eliminate unreliable workers and to build up the necessary human agency by giving training to suitable men.

The Cost Function

In large-scale surveys the question of expenditure is of decisive importance. This is why a careful study of the cost function assumes a special importance of its own in this connexion. It is worth noting, for example, that the theory of stratified sampling is appropriate only when the cost of collecting the information for any given number of sample-units is independent of the manner in which these sample-units are distributed over the field. This, however, rarely occurs in practice in large-scale surveys. In all our work we found that the cost was profoundly affected by the geographical distribution of the sample-units. This means that principles other than stratification are necessary for securing an efficient sampling technique.

I may say a few words regarding the cost function itself. We found that it is more convenient and more economical to study it separately from the variance function. We have also found that it is usually possible to split up the cost function into a number of independent components each of which can be studied separately. In the Jute Census Scheme we found that the cost of big journeys (for moving from one place to another) and of small journeys (for moving from camp to field and from one sample-unit to another) are functions of the density but not of the size of individual sample-units. On the other hand, the cost of actual enumeration, that is, location and inspection of sample-units and of other miscellaneous work are functions of the size but not of the density of sample-units. This naturally simplified the work considerably. Theoretically, of course, there may be interaction between size and density or between the different components of cost. In fact in our own work in 1938 and 1939 we had used a number of patterns to detect the effect of any such interaction. We found, however, that the interaction, if any, was negligibly small in the present case. I am inclined to think that this is likely to be true in many, if not in all, large-scale sample surveys.

The Variance Function

In the case of a truly binomial or Gauss-Laplacian variate the variance decreases inversely as the size of the sample-unit.

This may be called a variance function of the 'normal' type. Throughout our own work on area census as well as in crop-cutting experiments on paddy, wheat, jute, and sugarcane we found that in actual fact the variance decreases more slowly than this. This is why it is essential to ascertain the specific form of the variance function in each sample survey.

I have already mentioned that it is convenient to study the variance function independently of the cost function. Where suitable material based on a complete census is available, model sampling experiments can supply valuable information. In field work we have found multiple or nested sample-units to be extremely useful. This is only a large sample-unit which is subdivided into smaller units for each of which the information is collected separately. This makes it possible to study the variability for different sub-cuts as well as for different combinations of sub-cuts. The simple dodge of using an asymmetric division increases the range appreciably, and this is what we are now using as a standard procedure in our work.

Random and Patterned Fields

I may also refer briefly to certain theoretical aspects of the variance function. The deviation from a normal type may be most easily explained by the existence of a correlation between neighbouring regions. In fact in many ways it is convenient to think of the whole area under survey as a 'statistical field' in which the variate under consideration (such as the proportion of land under jute or the yield per acre of a given crop, etc.) has a definite value at each place. It is convenient to introduce the concept of a 'random field' in which the variate under consideration has a purely random space distribution. This naturally leads to the concept of 'patterned fields' in which the distribution of the variate is not purely random but has more or less regular features.

It is obvious that the nature of the variance function must be closely connected with the random (or non-random) character of the field. It is easy to see that a purely random field has a variance function of the normal type. We may conveniently think of the variate field to be divided into more or less homogeneous regions with the help of contour lines which may, without any loss of generality, be considered to be labelled by, say, (n) successive integers.

Let us consider a linear field in which these contour lines are distributed in a purely random manner. If we use sample-units of size (x) then the number of contour lines likely to be included within each sample-unit is simply proportional to (x). Thus, if (m) represents the number of contour lines covered by sample-units of size (x), then (m) is directly proportional to (x). But the variance of the mean of (m) numbers taken at random the official estimates is probably much smaller than that actually observed.

We may consider the question from a slightly different point of view. The total area under jute in Bengal is not a mathematical quantity which remains constant throughout the season. Plots sown with jute at the beginning of the season may go out of jute owing to the destruction of the crop by drought, or excessive rainfall and floods or through damage by pests, etc.; some of these plots, on the other hand, may be again sown with jute later in the season. The actual area under jute is thus, strictly speaking, a variable figure which fluctuates from day to day. On the whole, in normal years, the area will decrease from the time when sowings are completed till the crop is actually harvested. The difference between the official estimates at the beginning and at the end of the season supplies a rough idea of the shrinkage in area due to physical causes. In 1941 the actual decrease was about 90,000 acres which represents roughly six per cent of the total area at the end of the season. Halving this difference we get three per cent as the margin of uncertainty due to what may be broadly called purely physical causes. This suggests that no useful purpose would be served by trying to reduce the margin of sampling error below something of the order of three per cent. At odds of twenty to one this means a standard error of about 1·5 per cent or a probable error of about one per cent. In 1941 the estimated probable error of $\pm 17,000$ acres was of just this order which shows that the precision attained in 1941 was fully adequate.

SECTION OF PHYSICS

President :—B. B. Ray, D.Sc., F.N.I.

Presidential Address

(Delivered on Jan. 4, 1942)

SOME ASPECTS OF X-RAY INVESTIGATIONS ON SOLIDS, ELECTROLYTIC SOLUTIONS, ALLOTROPES AND COLLOIDS.

It is with great diffidence that I take upon me the task of presiding over the deliberations of this section of the Indian Science Congress. The polite words with which the Chairman of any meeting generally opens his mouth can scarcely express the feelings of one who is as much conscious of the greatness of his subject as of his own limitations. For, physics today has made gigantic strides and it now includes in its scope subjects which it is impossible for one single man to understand far less to master.

The subject which I have chosen to speak before you, is some of the achievements of X-rays in the field of physical research in which I am specially interested. Indeed X-rays have opened up so many new avenues of research in practically all the branches of science that it is impossible to present to you any general account of the progress made in different directions and even in a special subject like physics. I must confess that I have not been able to continue investigations in all branches of physics in which the developments made by X-rays are not only remarkable but have also helped us to understand some of the deep mysteries of Nature. Under these limitations I regret that you are to remain satisfied with discussions of a few problems which we are trying to solve by X-rays.

Firstly, I shall present before you a short account of the various theories of the solid state of metals and also some of the important observations of soft X-rays and then proceed to show that how a proper study of emission lines and absorption edges in this region has helped us not only to verify and in some cases modify the theoretical predictions made about conduction electrons in metals but has also thrown a new light on the mechanism of transition of electrons from one energy level to another inside an atom-system crystal. As is well known, soft X-rays are highly absorbed in air; so that the X-ray tube, slit system, and the plate holder with the photographic plate should be placed in a high vacuum. The region of spectra in which we are especially interested, viz. where conduction electrons are involved in transition, stretches from 5–400 A.U. This region covers the *K*-radiation of elements Li (3) to S (16), the *L*-radiation of elements Na (11) to Zn (30) and *M*-radiation of elements K (19) to Hg (72) and so on.

This region of spectra is divided for practical reasons into two parts—(*a*) 5–20 A.U. and (*b*) 20 A.U. upwards. In the first region (5–20 A.U.) investigations are carried out by crystals (Gypsum or Mica) bent generally to a radius of curvature from 50 cm. upwards and in the second region concave gratings of 1 to 2 metres radius are generally used. For wavelengths from 20–50 A.U. a grating of 5 to 7 metres radius is desirable. Rowland focussing method is adopted in both these types of experiments. For experimental considerations, concave grating of glass is preferable to both plane and metal speculum. As has been mentioned before, difficulties in the investigations of soft X-rays spectra are entirely technical but thanks to the ingenious experimental device made by Prof. Siegbahn, that instruments for both the bent crystal and the concave grating spectroscopy have been brought out almost to a perfection.

In the soft X-ray emission spectra of solids we are presented with broad bands along with some sharp spectral lines. These bands are due to the transition of electrons of the outermost level into a deeper vacant level which has lost one electron during the process of excitation. But when lines involving similar quantum transitions are excited from the substance in the vapour state by hot spark discharge method we get sharp lines as ordinarily found in optical spectra. This outstanding difference between the two spectra is, however, inherent in the very nature of the two physical states of the substance. In the vapour state, atoms move about quite freely and energy levels are quite sharp due to lack of interaction between atoms. In the solid state, however, the interaction between atoms is so strong that they are held firm in a regular lattice and the energy levels are profoundly modified. Energy levels of individual atoms are now replaced by the energy levels of the crystals as a whole which can be treated as a big molecule composed of an immense number of atoms. If N be the number of atoms in a piece under consideration, then it is evident that each energy band of the crystal will contain N levels corresponding to N atoms. In the case of deeper levels, all these N states will be confined within a very narrow energy limit (2×10^{-19} e.v. for Na—K level) so that ordinary X-ray lines arising from the transition in the deeper levels are quite sharp.

In the outermost level (the conduction level), however, these N states will be so widely distributed over the band of the crystal that the total breadth of the band becomes of the order of several volts. The number of states within energy range E and $E+dE$ is denoted by $N(E)$, dE where $N(E)$ is the density function of the states. In emission spectra, these N states will give rise to so densely packed lines that all of them will blend together forming one single broad band. If we neglect the broadening of the deeper levels to which the last bound electron makes the final transition, we can make an estimate of the density function $N(E)$ of the highest level. The intensity is given by

$$I(E) \sim N(E)f(E)$$

where $f(E)$ is the transition probability of the last bound electrons into the deeper level. The form of $f(E)$ must be found out theoretically. (In absorption process one of the inner electrons is photo-electrically knocked out of the inner shell and is accommodated in a higher unoccupied level. Hence we observe that a knowledge of the transition probability and intensity distribution over emission and absorption spectra enables us to compute the density function both in the occupied as well as the unoccupied regions of the conduction band.)

The free electron model:—The width and form of the intensity distribution curve can be calculated theoretically from the models assumed in various conduction theories. The models employed by Pauli, Sommerfeld, and others, assume that conduction electrons are freely moving in a constant potential within the lattice. Energy values corresponding to different stationary states of free electrons within the potential box are calculated with the assumption that each state can accommodate two and only two electrons in accordance with Pauli's exclusion principles. The energy of the highest occupied level is given by

$$E_{\text{max.}} = \frac{h^2}{2m}\left(\frac{3n}{8\pi}\right)^{\frac{2}{3}},$$

where n is the number of free electrons per c.c., and the density function $N(E)$ is given by

$$N(E) = 2\pi\left(\frac{2m}{h^2}\right)^{\frac{3}{2}}E^{\frac{1}{2}}.$$

Houston[1] first calculated the transition probability $f(E)$ of the 'free' state into a deeper symmetrical K-level and found that $f(E)$ varies as E and thus $I(E) \sim E^{\frac{3}{2}}$. The levels above E for $E_{\max}$ will be completely unoccupied at room temperature due to high degeneracy of the electron gas, because the energy $E_{\max}$ is extremely large in comparison with the average gas kinetic energy ($3KT \sim \cdot 071$ e.v. at room temperature, $E=13\cdot 2$ e.v. for Al). Since there are no electrons above $E_{\max}$ the intensity

$$I(E) = 0$$
$$\text{for} \quad E > E_{\max}.$$

The most striking conclusion is that the intensity will rise approximately as $E^{\frac{3}{2}}$ at the long wavelength side of the band and will be suddenly guillotined at E_{max}.

Nearly free electron model (*Peirles*) :—In Sommerfeld's theory the periodic field of the positive nuclei regularly arranged in the lattice is completely ignored. In a more detailed calculation by Peirles, Brillouin and others[2] a small perturbation with the periodicity of the lattice is introduced in the potential term with the result that the density of states is no longer a monotonic function of the energy. Discontinuities will occur at energy states corresponding to which the De-Broglie waves suffer Bragg reflection from the lattice planes. The whole energy continuum of free electrons will thus be divided into zones of allowed and forbidden energies. The structure of the intensity curve at the head of the emission band towards the short wavelength limit will, therefore, depend upon two factors.

(1) The crystal structure of the lattice to which the zone structure is obviously due, and (2) the number of free electrons per atom which determines the limit of the unoccupied zones.

The real form near the head of the band will be completely determined by the nature of the zone near the highest occupied level. At the bottom of the level, electrons will behave like free electrons gas as before because the corresponding ψ waves will not be much modified by the perturbation term. The tail of the energy band will, therefore, be almost the same as in the case of free gas.

The bound electron model (*Bloch*)[3] :—In the nearly free electron model the perturbation introduced in the potential field is small in comparison with the kinetic energy of the free electrons. But in the *bound electron model*, the perturbation term is assumed to be large in comparison with the kinetic energy of the electrons with the result that the density of the states becomes somewhat different. The density function $N(E)$ is very difficult to evaluate analytically and a rough graphical integration gives a symmetrical curve at a position corresponding to the discrete atomic function. In this model, energy states also consist of allowed and forbidden zones corresponding to those in isolated atoms. The width of these zones depends on the exchange integral (γ).

From such a model the intensity of an emission band in a metal will fall suddenly from some definite positive value to zero as E is increased beyond E_{max} at which the surface of the filled electrons occurs. Absorption, however, will set in suddenly when the absorbed quantum has sufficient energy to carry an electron from an inner shell to a level of energy just greater than E_{max}. These sudden jumps in the emission and absorption curves are termed 'emission and absorption' edges and according to the theory, they should obviously occur at the same wavelength. It is satisfactory to note that in conductors for which we have necessary data 'the absorption edge of a metal agrees in wavelength with the corresponding emission edge'.

This simple electron gas theory, after Sommerfeld, which neglects the lattice structure altogether and treats the valence electron in a metal as a free electron gas can only be regarded as a first approximation. Indeed this theory would always give $N(E) \sim E^{\frac{1}{2}}$ but Mott and Jones [4] have shown that $N(E)$ curves are really complicated with several peaks. when the crystalline lattice field is taken into consideration. Since the area under the theoretical $N(E)$ curve up to the limit of the filled levels ($E_{\max}$) must be proportional to the number of conduction electrons per atom, it is evident that the band-width may either be greater or less than Sommerfeld-width according to the form of the characteristic $N(E)$ curve and the exact position of the value of $E_{\max}$ on it.

Thus, when comparing the results of the experimental observations with the theoretical formula (Sommerfeld), we are left with a certain amount of uncertainty.

The equation connecting the intensity of the emission band $I(E)$ and the density of states in the valence level $N(E)$ can be written down as

$$I(E) \sim f(E)\ N(E), \qquad \text{where } E \leqslant E_{\max}.$$

Here $E_{\max}$ is the maximum energy of the filled levels and $f(E)$ is the transition probability of the electron. Owing to the presence of the factor $f(E)$ which depends on the precise wave function of the electrons in the normal and excited states and which controls the transition probabilities, $I(E)$ can only be expected to represent $N(E)$ directly in a very qualitative way. There are some important properties of the bands which do not depend on $f(E)$. According to the theory of metals, the difference between a metal and insulator lies in the fact that in the former there are unoccupied levels inside the valency band, while in the latter it is completely filled up. In a metal, therefore, an electron in the valency band, when slightly accelerated under an applied electric field, can still remain in that band and move about freely throughout the crystal contributing to electric conduction, while in an insulator there is no such space available for such an electron to move up and thus it becomes a non-conductor. Even if the electrons in the valency shell are completely filled up according to Pauli principle, as in two-electron metals, still conduction is also possible due to the overlapping of the valency band with the one just immediately above it. The case of semi-conductor is considered as intermediate between these two cases.

It is curious, though Sommerfeld's theory does not give a true picture of the structure of the emission band, for want of any better theoretical formula we have no alternative but to adopt it for comparing the experimental results on band-widths of metals of the first two groups of elements.

In actual measurement of the band-width, however, we are faced with another serious practical difficulty. Either from Sommerfeld's theory or from more rigorous treatment by Mott and Jones, the emission band should have a definite beginning (on the low energy part of the band) where a gradual rise in intensity is predicted and while on the other side (higher energy side) a very rapid fall should occur. In practice, however, the structure of the band is found to be quite different. In the low energy part, the band tails towards longer wavelengths. This tailing effect is very large for the L_{23}-bands * and its breadth may be as great as the band itself. In the K-spectrum, the tail is not so prominent as in L_{23} but it is actually present. Its width may be as high as 3·4 volts in different substances.

This unexpected tailing effect makes the comparison of the experimental result with the theoretical formula extremely difficult and we only wish that this tail did not exist. In order to find the exact position of the band on the low energy side of the spectrum, Jones, Mott and Skinner [5] have from theoretical consideration on the mechanism of the emission *spectra* in the soft X-ray region concluded that the behaviour of transition probability $f(E)$ in the equation for intensity, depends entirely on the final state, i.e., whether it is a s-state (K-band) or p-state (L_{23}-band). They have shown that at the low energy limit of the emission band, i.e. for *smaller values* of E

$$\begin{aligned} I(E) &= \text{Const. } E^{\frac{3}{2}} \text{ (final } s\text{-state, } K\text{-band)} \\ &= \text{Const. } E^{\frac{1}{2}} \text{ (final } p\text{-state, } L_{23}\text{-band)} \end{aligned}$$

It may be mentioned here that Sommerfeld's theory *does not* show any difference in the intensity distribution for the K or L-bands at the low energy limit. Experiments on the K-band by O'Bryan and Skinner [6] on Be, by Karlsson and Siegbahn [7] on Al and Mg, by Farineau [8] on Mg, Al and Si, by Ray and Bhowmik [9] on Na, Mg, Al, Si and a similar study on the L_{23}-band on Na, Mg, Al, etc., by Siegbahn and Magnusson [10] and also by Skinner,[11] show definitely (neglecting the tail at the lower energy limit of the band) that the nature of the rise in the intensity curve from both these types of spectra (K and L) are entirely different. This no doubt suggests the general correct-

* When a conduction electron makes a transition to the K-shell, we call it a K-band and similar transition to L_2 or L_3 is termed as L_{23}-band. Where the separation between L_2 and L_3 is very small, both of them appear as a single band (L_{23}).

ness of the theoretical deductions by Jones, Mott and Skinner. As the fraction of the total radiation in the tails is extremely small (specially in L_{23}), Skinner[12] first interpolated the intensity curve according to the theory near the tail as $I \sim E^{\frac{1}{2}}$ for L_{23}-bands and $I \sim E^{\frac{3}{2}}$ for K-bands to cut the E axis to find the actual beginning of the band. This treatment no doubt eliminates the tail from the measurement of the total breadth of the emission band but even now it is found that it does not compare favourably with the theoretical workable formula (Sommerfeld). Skinner now adopts another method to locate the actual beginning of the band, which considerably reduces its width. In L_{23}, this is done by a *linear* extrapolation of the intensity curve near the tail and for K-spectra a similar extrapolation as E^2 is used to define the beginning of the emission band. This method of reducing the band-widths is rather empirical and is not required from any theoretical consideration and the measurement of its width after making such an empirical correction is termed as 'reduced band-width' and the latter now agrees favourably with the theoretical formula (Sommerfeld). Another complication of a serious nature has been pointed out by Ray and Bhowmik in K-spectra of the second group of elements by the appearance of satellite or satellites just on the foot of the band on its long wavelength limit. Structures of these satellites are rather complicated and they unfortunately appear in the region for small values of E, where from theoretical considerations $I(E)$ should vary as $E^{\frac{3}{2}}$. The actual intensity distribution of K-band near this region (for small values of E) is so much altered by the presence of these satellites that any extrapolation of intensity curve (after Skinner) near the tail now becomes very difficult and involves an error of 1 to 2 volts in this region alone. On the other hand, Skinner has shown that the total width of the emission edge, i.e. the distance in volts from the maximum intensity of the band to the point where it is zero, in the L_{23}-bands of the elements of the first two groups of elements is of the order of 1/10 e.v., while Ray and Bhowmik have pointed out that similar emission width in K-series of elements of the second group of metals is of about 2 volts. They also report that in the K-emission edge, the fall of intensity is not so sharp as in L_{23} and the actual structure of the emission edge is also profoundly modified (especially in Al K-band) by the superposition of the absorption edge arising from the surface of the anticathode itself. This phenomenon can be clearly seen by changing the exciting voltage in the tube. The high voltage (8 kV.) spectrum of aluminium has not only a sharp band head at the short wavelength limit but the general radiation in this case is comparatively smaller on the short wavelength limit than that on the long wavelength side showing clearly the effect of general absorption by the anticathode; but if the spectrum is excited at a low voltage (1·5 kV.) the general radiation on both the sides of the band is the same showing the absence of absorption of general radiation. The fundamental nature of the intensity curve is now altered. A comparative study of the two spectra shows that while the high voltage curve has a sharp edge at the band head, the low voltage spectra shows no such edge. On the other hand, the latter shows that after reaching I_{max}, the intensity falls gradually but sharply till it reaches a point, after which it follows a precipitous line and a kink is observed in the photometric curve at this point. But unlike Al, Mg spectra for both the high and low voltages are similar. Thus in determining the short wavelength limit of the band, great care should be taken to avoid the absorption effect of the anticathode and this can be done by exciting the emission band at a very low voltage. The apparent structure of the emission edge as is generally found in high voltage spectra really consists of two parts, viz. the structure of true emission edge and that of the true absorption edge. Both of them unfortunately appear in the same position and in order to find the structure of the true emission edge, a knowledge of intensity distribution of the apparent emission and that of the true absorption edge is essential. The determination of this structure has been undertaken by Mr. K. Dasgupta and his final results are awaited with interest as it will be able to test the validity or otherwise of the theoretical predictions of the solid theory of metals.

So far we have only considered the structure at the head and the tail of the emission band but the results on the nature of the main K-bands are somewhat conflicting. Thus, some find a *hump* on the main K-bands of Al, or Mg on the lower wavelength side of the emission edge which sometimes appears as a doublet in Si band. Before discussing the origin of these complications, we may mention that not only structures of K-bands of pure metals and their oxides but also their relative positions on the wavelength scale are also different and the resolution is not sufficient to separate them entirely on the photographic plate for these elements. Oxide K-bands are found to be shifted on the longer wavelength side than those from pure metals. The anticathode of any pure substance in the X-ray tube sooner or later becomes contaminated with a slight coating of oxide, if sufficient precautions are not taken, and both the spectra (from pure element and its oxides) are now supperposed on the same plate and the intensity of the *hump* depends now entirely on the percentage of oxide formed during the time of exposure. Thus the hump on the Al K-band found by Farineau as quoted by Skinner (*l. c.*) has been found by us to be entirely due to the oxide impurities and we have also found that K-bands of pure solids like Mg, Al and Si are without any hump or peak though the rise in intensity is different for different elements. This observation is further supported by the fact that the difference in volts between the main K-band of metal and corresponding oxide is the same as found between the hump and the maximum intensity of the main metallic band.

Skinner reports a doublet structure in L_{23}-band of pure silicon. We have also found such a doublet in the K-band of the same element and have shown that of the two bands, one is really due to the pure element and the other is from oxide. Further, we have roughly calculated the voltage difference between the bands in the L_{23}-spectra of silicon and have found that this difference agrees fairly with the separation as given by Skinner. Thus it seems that the doublet structure of the L_{23}-spectra in silicon as observed by Skinner is really due to the superposition of the metal and oxide bands. Skinner reports a doublet structure in L_{23}-band of SiO_2. We have observed a similar doublet in the K-band of the same compounds and the origin of such a structure has been ascribed by us as due to the same cause, viz. superposition of K-bands of SiO_2 and Si, where the former has partially been reduced to the metallic state.

K-bands of the first group, L-bands of the second group have been studied by Siegbahn and Magnusson and also by Skinner and his associates. Skinner has summarized these results and remarks that 'there is no doubt that we are dealing with an intrinsic difference between metals and non-metals. The metals show true emission edges while the non-metals show the phenomena of false edges and band heads. It is interesting to note that the bad conductors like B, C (graphite) and Si fall very definitely into the latter category, showing that if a true edge exists, it must be entirely negligible in magnitude. From the spectroscopic point of view, the behaviour of these substances is indistinguishable from that of insulators'. Lindh [13] and his associates have shown that the K-bands of sulphur and phosphorus are also complicated where such 'false edges' as noticed by Skinner are also present. From these observations together with ours on silicon and phosphorus on the K-band, we have shown that bad conductors and non-metals are so easily oxidised under electronic impact, that it is almost impossible to photograph pure spectra of these elements. The spectra of elements and their oxides are further complicated by the fact that spark-lines or satellites appear both on the short and long wavelength side of the main band. We have shown that not only these elements are easily oxidised but oxides like SiO_2 are also partially reduced by electronic impact. Thus it appears to us that the most of the 'false edges' as noticed by Skinner for non-metals might be explained as the superposition effect of spectra (with their spark-lines and satellites) of pure elements and oxides. Further, the difference in volts between two main bands in non-metals agrees fairly with experimental results of pure elements and its oxides. The intensity variation of these bands on the superposed spectrum really gives a false impression of a 'false edge' when observed under different conditions of excitation.

Skinner has performed a set of most difficult and ingenious experiments on emission edges of metals both in K-spectra of Li, Be and L_{23} of Na, Mg and Al at different temperatures. These experiments are not only laborious but also require technical knowledge of a high order. He has definitely shown from the general diffuseness and shift of the main emission edge at different temperatures that the theory of solids so far as it considers electrons in the Fermi-Surface in the valency level, correctly represents the true picture.

It is inherent in the theory of solid metals that energy levels of an individual atom are replaced by energy levels of the crystal as a whole with the result that the outermost level now become very broad. The breadth of the outer level may be such as to penetrate into the region originally occupied by the next higher one and we get a resultant level which is a mixture of two neighbouring levels or zones. As an example, we can consider the cases of Mg and Al. In the normal *atom* of Mg we have two electrons in the outermost 3*s* level. But in the Mg metal this level (3*s*) is so much broadened that they penetrate the next higher level, viz. 3*p*, which is also broad. In an aluminium atom, the outermost level is 3*p*, which is also broad, penetrates into the deeper 3*s* level in the solid state. In both these metals (Mg and Al) admixture of 3*s* and 3*p* occurs. Jones Mott and Skinner (*l. c.*) have shown in such an admixture of levels, both *s* and *p* electrons not only do simultaneously exist throughout the combined level but also retain their particular individuality. They have further calculated the probabilities of finding *s* and *p* electrons in such a combined zone and their general finding is in accordance with the intensity curves of K and L-bands where *p* and *s* electrons are respectively responsible for their structures. In order to explain the origin of long tails specially in L-bands as mentioned before, Skinner has made an ingenious suggestion. The theory of solids does not throw any light on the origin of any tail which finds a ready explanation in the Auger process the importance of which has already been shown by Kronig and Coster [14] in X-ray spectroscopy. Skinner suggests that the Auger process is more important in the soft X-ray region. It may be explained in this way. Suppose an electron is knocked off from L_1-level; from probability consideration, a non-radiative transition can occur from L_2 or L_3 to L_1, the energy of which is absorbed by a suitable electron in the valency level and the latter now leaves the atom as a photoelectron. This process (Auger) decreases the life of an atom in that state in comparison with others and thereby broadens that particular level. In any atom for the same total quantum number, there are different sets of sublevels designated as L_1, L_2, L_3 or M_1, M_2, M_3, M_4 and M_5 and so on and in any such level, non-radiative transition due to Auger process is more probable from those sublevels which have a smaller k value or in other words L_1 will be broader than L_2 which again is broader than L_3. Similar consideration will also hold good for M and N shells. This simple suggestion perhaps agrees qualitatively with general observations made on the breadth of different sublevels. Skinner suggests that even in an admixture of levels, this non-radiative transitional probability of different electrons such as s and p is still retained. He has further shown that the probability of finding s electrons is large in comparison with p electrons at the bottom of the combined level. As these s levels are now broadened by Auger process it will show a broadening effect on the low energy portion of L-bands, or, in other words, the tail now appears and will be superimposed on the main band. In L-bands (in Mg, Al) we are concerned with transitions from $3s$ to $2p$ while K-bands originate from $3p$ to $1s$. As energy levels of $3s$ electrons are broadened by Auger process, the tail becomes prominent in L-spectra. This suggestion now finds a ready explanation for observed longer tail in the L-bands. Whether such an enormous long tail in L_{23}-bands and a still smaller tail in the K-spectra can be explained by this simple process still remains an open question. Fröhlich and Bouckaert have, however, shown that on 'free electron gas' theory, energy level of $3s$ electrons near the bottom of the level may be as broad as 2 volts by Auger process. It may be mentioned here that though structures and also empirical corrections for neglecting the tailing effect for K and L series are different, reduced band-widths when measured in volts are the same from both these spectra (K and L).

It has already been mentioned before that main bands (K, L or M) in the soft X-ray region are always accompanied by satellites which may generally be classified in two groups, viz. having line and band structures. The latter are sometimes found to have a form similar to those of parent bands. These satellites are not only present in pure elements but also in compounds both polar and nonpolar. O'Bryan and Skinner [15] have put forward a suggestion which seeks to explain the origin of these satellites. It may be summarized as follows; 'When an electron from an X-ray shell is removed by electron impact the valence electrons are subjected to an increased field of force, on account of the increased core charge, two possibilities may arise:

(1) The system of valence electron levels may be unaffected by the altered field of force of a single nucleus, and no new valence levels appear.

(2) The valence electrons associated with a particular atom may be "sucked in" by the increased field of force to form sharp levels of "atomic" character.

We may call these "non-atomic" and "atomic" intermediate states. The atomic type of state may be expected in the case of very polar compounds; the non-atomic type of state must certainly be assumed to occur in the case of metals.'

When two electrons are simultaneously knocked off from X-ray shells, these two possibilities may also occur. Further, we can imagine that in any ionic crystal owing to statistical fluctuations of the number of electrons, any atomic centre can be temporarily neutral. X-rays when excited from such neutral centres may be a line or band depending on whether the final state after the 'emission of radiation has atomic or non-atomic character'. The determining factor for the occurrence of such line or band satellites will evidently depend on the difference between (*a*) the time of passage of a conduction electron from atom to atom in the ionic crystal (order of 10^{-15} sec. in a metal), and (*b*) the time of emission process in any exciting centre (order of 10^{-13} to 10^{-14} sec. having smaller value for radiation of shorter wavelength). If the former is of the same order or larger than the latter, satellites will be lines and they will lie on the short wavelength part of the main band. This perhaps explains the origin of line satellites found for the *K*-radiation of fluorine and oxygen emitted from fluorides and oxides but other lines or bands on the longer wavelength side remains, however, unexplained. While on the other hand if a conduction electron strays into the valency band before an actual emission has taken place, satellite band will appear and favourable cases for such an occurrence are metal-ion spectra of the oxides where such a band is actually observed on the long wavelength part of the main band. The origin of other satellites bands found on both the sides of the main one observed in metal-ion and *also in solid metal* spectra has not yet been properly understood. Another serious doubt as to the validity of this suggestion may be raised on the question of relative intensity of main bands originating from metal-ion and neutral atom in compounds like MgO and Al_2O_3. It is natural to assume that in these compounds the number of metal-ions will surely be larger than neutral atoms, but actually it is found that L_{23}-bands from metal-ion are much weaker than that which is supposed to have originated from neutral atom while the intensity relation from corresponding *K*-bands (from metal-ion and neutral atom) of the compounds are quite reversed and O'Bryan and Skinner have sought to explain this anomaly by a sort of Auger process. In this connection partial corroboration of the existence of neutral atoms, like those found in solids, in metal-ion compounds can be traced from recent experiments of Mr. K. Dasgupta on *K*-absorption edges of Al, Mg, Si and their oxides and also on absorption edges of Al and Si in mica, which is known as one of the best insulators. In Al_2O_3 he has found a weak absorption edge in the *K*-region corresponding to that found for the solid metal along with a more prominent one evidently belonging to the oxide. Aluminium *in mica* shows one weak absorption at the same position as found in the metal itself but the second and the strongest absorption edge does not exactly correspond to that from Al_2O_3. In MgO the first weak absorption edge corresponds to that of the metal while the second one on the short wavelength side beongs to the compound itself. In SiO_2, the observations are the same as found for MgO. But in mica, no trace of absorption edge corresponding to that of silicon metal is to be found and the first absorption edge of Si (in mica) does not exactly correspond to that of SiO_2 while two other secondary absorption structures are found on the short wavelength side of the main band. In the silicon dioxide, we have also found a trace of the absorption edge belonging definitely to Si. From these absorption experiments of Dasgupta, traces of pure element in the solid form are found to be present in all oxides of these elements (also of Al in Mica); whether this reduction of oxides to the metallic form is due to the absorption of soft X-rays by these compounds is still an open question. At the same time, pure solids like Mg, Al and Si do not show any trace of any absorption edge corresponding to their oxides. According to the suggestions made by O'Bryan and Skinner (*l.c.*), neutral atomic centres of Mg and Al are also possible under electron impact along with more numerous metal ions in solids like MgO and Al_2O_3. Absorption experiments of Mr. Dasgupta clearly suggest that the former will of the same type as found for solid elements. It is well known that the metal-ion spectra in the $K\alpha$-group are, however, sharp and clearly shifted on the wavelength scale with respect to those of the solid element and they are also very much stronger than the β-group. In experiments on the K-emission spectra for MgO, Al_2O_3 and mica, we have not been able to find any trace of spectra of α and β groups from neutral atomic centres of these elements, though these spectra should be very near to those of solid metals; at the same time, emission spectra from both Si and SiO_2 show clear sign of oxidation and reduction respectively, under electron impact. Experimental results on emission and absorption spectra at present lead to contradictory conclusions and whether the reduction of oxide to the metallic form is more probable and stable by the absorption of soft X-rays than by electron impact is yet a matter of speculation and further investigations are necessary before any definite conclusion can be reached on this problem.

Another interesting suggestion, based on experimental evidence, has been put forward by O'Bryan and Skinner (*l.c.*), in the soft X-ray region of solid chemical compounds in a lattice of atoms or ions of more than one sort. Herein lies the possibility of observing spectra of two or more kinds of atoms from the same given compound. Of course, it is not possible to observe all the component spectra on account of technical and other difficulties. O'Bryan and Skinner have, however, made observations of a large number of compounds suitable for analysis. The results are that K-spectra of O (or N) are quite different from the corresponding K or L-spectra of metal-ion which are rather complicated. K or L-spectra of Mg and Al in the solid state are again different from those of the oxides MgO and Al_2O_3 and so on. Of all the properties of soft X-ray bands, those of metal-ions are found to be very complex and observations on the similar form of the Mg L_{23} and the O(K) spectrum in MgO show conclusively that in this case we have to deal with the effect of symmetry interchange of wave functions. Those levels of the lattice which have $2p$ character when referred to the oxygen centres (for O K) have $3s$ character referred to the Mg centres for L_{23}-band and though less distinctly seen, the L_{23}-spectra of Al in Al_2O_3 and O K in the same oxide show similar characteristics. They have further established a sort of correspondence between the K-spectra of the negative ions with the high energy part of the K-spectra of the metal-ions in BeO and B_2O_3 and BN. In order to explain these facts they suggest another type of symmetry interchange effect. 'Main K-bands of B and Be in BeO, B_2O_2 and BN have a formless structure and are explained as the $2s$(O) band (when referred to oxygen atom in the lattice) which does not show itself in the K-spectrum of oxygen owing to the selection rule. This means that $2s$(O) wave functions in the lattice become $2p$ (Be) wave functions in BeO. At the same time, it has been experimentally found that at the higher energy region of the observed K-spectra in BeO we have weak structures which show some of the properties of the oxygen spectra. Hence we must assume that some of the $2p$(O) wave functions correspond to $2p$(Be) wave functions, the probability of such a correspondence being however small' and from intensity relation it is of the order of 10%. These generalizations are further corroborated by the fact that widths of these spectra mentioned above are of the same order of magnitude as the $2s$(O) or $2p$(O) bands in different cases, the former has no structure having a width of about 10 e.v. while the latter has a structure with a width varying from 13–20 e.v. The idea of symmetry interchange effect in an ionic crystal is quite novel and seems to explain some of the complexities found in spectra of metal-ion compounds. In homopolar compounds such as SiC, the symmetry interchange effect is practically absent and spectra of different atoms such as Si and C do not show any such similarity.

These are some of the recent observations on soft X-ray emission spectra. I have tried to present to you how they have corroborated the existing theory of solids and in some cases, have put new but interesting data before the theoretical physicist for the proper understanding of the subject.

Bloch's theory of solid metal as extended by Kronig [16], has been responsible for the proper understanding of a peculiar phenomenon in the X-ray absorption process, viz. the appearance of secondary absorption edges on the shorter wavelength side of the primary. Lindsay and his associates [17] first noticed that in solids there are fluctuations of absorption coefficient, showing maxima and minima immediately after the principal absorption edge towards shorter wavelength, extending over some hundreds of volts. These fluctuations in the absorption coefficient have been variously referred to as 'Fine Structure', 'Secondary Structure', 'Secondary Absorption Edge', etc. Investigations on this subject made by Lindsay [17], Coster [18], Hanawalt [19], Lindh [20] and others have clearly shown that (*a*) extended secondary structures are always found for metals, alloys, solid compounds and polyatomic molecules, and never arise from monatomic gases or vapours, (*b*) the nature of secondary edges depends mainly on the crystalline structure of the solid (whether polar or non-polar) and is greatly influenced by the temperature of the absorbing sheet.

According to the theory of solids, secondary edges are always possible wherever there is atomic aggregation and the latter may be polymolecular or crystalline (both polar and non-polar) and the intensity and the positions of the secondary edges will mainly depend on the field round the exciting atomic centres. This theory has been completely verified in metals and alloys but in polar compounds, however, the position and intensity of secondary structures do not conform to this simple theoretical prediction. For example, the positions of the maxima and minima as well as their nature are different for potassium and chlorine when they are studied in the same KCl crystal. Without dilating on the differences between the theoretical and experimental results on the spectra from polar compounds (or crystals) we can at once see that a systematic investigation on secondary absorption spectra presents us with an alternative method for a proper study of the true nature of the solute in solution. For practical difficulties, the region covered by 1·9 to 1·3 A.U. is found to be suitable for such a study and we have chosen the following compounds of iron and cobalt in *K*-absorption spectra for our experimental investigations.

Iron: Iron metal; $Fe_2(SO_4)_3 \cdot 9H_2O$; $Fe(NO_3)_3 \cdot 9H_2O$; $FeCl_3 \cdot 6H_2O$.

Cobalt: Cobalt metal; $CoSO_4 \cdot 7H_2O$; $Co(NO_3)_2 \cdot 6H_2O$; $CoCl_2 \cdot 6H_2O$ and also Cobalt Nitrite.

These compounds were at first dissolved in water, spectra from different dilutions beginning from the concentrated one up to ·05 *N* were in every case photographed along with the corresponding solid for comparison. For still lower concentrations, definite results cannot be obtained at the present moment for technical difficulties.

We can thus summarize our results on solution:

(*a*) Though the position of the principal absorption edge has suffered a small shift from compound to compound in the pure solid form, the secondary edges always extend to some 200 volts from the primary edge and they are found to be very pronounced near the main edge.

(*b*) In solutions, the secondary structures extending over 200 volts are observed up to a concentration of $\cdot 1\,N$, but the sharpness of these edges beginning from a higher concentration of $2{\cdot}55\,N$ to $\cdot 1\,N$, gradually decreases. Below $\cdot 1\,N$, the secondary structures are generally very diffuse.

(*c*) Though positions of some of the maxima and minima have come out almost the same both *in solid state and in strong solutions*, the intensity relation of those edges far away from the main edge is found to be entirely different.

(*d*) Below $\cdot 1\,N$, this discrepancy is very marked and a complete change takes place at about $\cdot 05\,N$. At this concentration, secondary spectra are only marked by two diffuse white bands separated by a sharp dark line. The secondary structure beyond the second white band cannot be located with certainty.

(*e*) It is interesting to note that the position of the principal absorption edge is almost the same in solids and in corresponding solutions up to a concentration of $\cdot 1\,N$, and at still lower concentrations it *shifts to the longer wavelength side.*

The persistence of secondary edges even in solution clearly suggests that we are dealing with exciting centres which are neither purely atomic nor ionic in character. Though Debye and Huckle's theory of complete dissociation of strong electrolytes is found to be correct only in dilute solutions, it clearly fails in higher concentrations. From experiments of Fajan[21] and his associates on the refractivity measurements of dilute and concentrated solutions of KF, NaI, etc., and also from the experiments of osmotic pressure of $MgSO_4$ and other solutions in water, it is clear that even in 1/500 mol. solution (for $MgSO_4$)[22] there are at least 20% of neutral molecules. On the basis of the existence of a sufficient number of neutral molecules we can only find a reasonable explanation for the persistence of secondary absorption edges even in dilute solutions ($\cdot 05\,N$).

Further, if observed secondary structures are due to isolated single molecules alone, it is difficult to understand why in strong solutions there should be a certain similarity with the secondary structure obtained from the corresponding solid. In a recent investigation, Drynski and Smoluchowski[23] have shown that secondary structures of $GeCl_4$ in the solid and in the gaseous state are different. This is because of the fact that in solid, the molecules are further regularly arranged so that the secondary structures arise firstly from the arrangement of atoms in each molecule and secondly from the arrangement of molecules in the solid crystal. The similarity of structures in solid and in solution at a high concentration naturally suggests that even in the latter the solute molecules profoundly influence each other. Below $\cdot 1\,N$, the nature as well as the distances from the main edge of the succeeding maxima and minima gradually suffer a change.

At still lower concentrations we are presented with a completely different picture. As the concentration diminishes, the number of neutral molecules also decreases and consequently the intermolecular attraction diminishes. At concentrations such as $\cdot 05\,N$, therefore, we shall have to consider the following factors:

(1) There are neutral molecules whose number is small.
(2) There are dissociated ions whose percentage is very great, and positively and negatively charged ions are distributed as contemplated by Debye.

Even ionized Fe or Co atoms with ionic atmosphere (Debye) have a field of force which is different from pure intermolecular force (as in solid or in strong solutions where the undissociated molecules have a strong influence on each other). The primary absorption edge of this type of ionized atoms will naturally be shifted towards the shorter wavelength side of the spectrum, but the experimental results show that in a very dilute solution ($\cdot 05\,N$) it shifts to the reverse direction.

From this, we are to conclude that the observed peculiarities of the main absorption edge in such a dilute solution are really due to undissociated molecules where their mutual influence is almost absent. The undissociated molecules in such a dilute solution may be treated as those in the vapour state. The appearance of the white line near the primary edge is perhaps due to the field between metal and other radical in the molecule itself. As mentioned before, the similarity in structure between solids and strong solutions naturally suggests that in the latter the mutual influence (intermolecular) between the neutral molecules is still strong and with increasing dilution this force gradually decreases and the structure at dilution $\cdot 05\,N$ is only due to neutral molecules. At any intermediate dilution (such as

·5 N), structures arising both from inter-molecular and intra-molecular forces are perhaps superposed on the same absorption spectrum. The experimental data which we have obtained so far in solution with respect to secondary structures are by no means sufficient. The region of concentration from ·05 N downwards appears to offer interesting results. Due to experimental difficulties we could not at present explore this region for all substances. We hope that the investigation in this region, though difficult, will be made possible with improved experimental technique and expect definite results regarding the nature of ions in solutions.

Experimental investigations on different aspects of the theory of solids have not yet been fully explored and it is interesting to note how such a theory places before us a new method for attacking an old problem which was raised long ago by the Indian Seers of the Upanishads, viz., 'What is the true nature of ultimate particles of common salt when it is dissolved in water?'

The study of the number of atoms or molecules, their arrangements and relative distances between them in the unit cell of any crystal by X-rays began only thirty years ago and during this period its achievement is really striking. It has not only corroborated and even modified the earlier works of pioneers of crystallography but has also penetrated deeply in a branch of science in which the organic chemists could only instinctively suggest the structure of organic molecules to correlate their experimental results. The application of X-rays is nowadays not only confined to the study of the ultimate unit cell in any crystal both organic and inorganic but it has also been successful in determining the distance or distances between neighbouring atoms in complex organic molecules and with its help the reality of the existence of single bond, double bonds, etc., as conceived by organic chemists has been clearly demonstrated. Its importance can be judged by the fact that nowadays no data on any crystal are accepted as final without a complete analysis of the crystal by X-rays.

For complete analysis, the size of the single crystal should not be too small but during the last great war, Hull in America and Debye and Scherrer in Switzerland, have shown that we may profitably use the powder method even when the size of single crystals is small, i.e. in a powdered form, where sharp diffraction rings are obtained revealing their inner structure; but this (powder) method has its limitations and can only be applied in a limited number of groups of crystals. It has, however, opened a new field of investigation where a distinction can be made between amorphous and crystalline solid; the former shows broad band or bands while the latter reveals sharp rings, the intensity and position of which depend on the lattice structure of the crystal. Again if the powdered crystal be less than

10^{-5} cm. in diameter, in places of sharp diffraction rings broad and diffuse bands appear as in 'amorphous solid' and any sharp distinction between a truly crystalline or an amorphous state is entirely lost. Scherrer[24] first showed that with small particles of MgO, broad and diffuse diffraction bands appear in places where sharp and intense rings are expected from large powdered crystals. Similar observations on different substances really lead us to doubt the existence of any true amorphous solid. Laue[25], from theoretical considerations, has shown that due to incomplete interference, small particles, even though they are crystalline, will appear as broad bands, and from the measurement of their breadth, it is possible to obtain some reasonable idea about the size of crystallites of certain types but the sizes so determined do not compare favourably with those obtained from other chemical methods which are also only approximate. Two definite conclusions can be drawn from the X-ray diffraction pattern. As the size of the powdered or amorphous particles gradually increases (generally with the application of heat) (*a*) the broad bands become narrower and sharper till with sufficient increase, sharp lines do appear and (*b*) the '*d*' value of the bands increases or decreases depending upon the type of binding in the crystal, e.g. whether it is non-polar or polar.

Allotropic modifications can be best studied by X-rays. Of course, if the crystals of these allotropes are large (such as are found for diamond, graphite and carbon) it is rather easy to find their different physical properties. But when they are obtained only in the powdered form, perhaps it is very convenient to study their inner structure and hence their properties by X-ray diffraction method.

The element sulphur, according to chemists[26], shows under different physical conditions a number of allotropes, the properties of which evidently depend on the method of their preparation. Of all these varieties, large single crystals of $S\alpha$ (orthorhombic) and $S\beta$ (monoclinic) only can be prepared for complete X-ray analysis. But other allotropes are always obtained in the powdered form and the Hull method of analysis can only be profitably used to determine the crystallinity or otherwise of those varieties. Those allotropes of sulphur which are generally considered to be amorphous, are prepared by different chemical methods. These are: (1) Milk of Sulphur, (2) Colloidal Sulphur, (3) White Sulphur, (4) Plastic Sulphur.

Sulphur, crystallized from a cold solution of CS_2, forms an orthorhombic system; ordinary roll sulphur and flower of sulphur also belong to this class. From analysis, Warren and Burwell[27] find that this variety of sulphur has a space group V_{24}^{h}; the size of the unit cell being $a = 10{\cdot}48$, $b = 12{\cdot}92$ and $c = 24{\cdot}55$ in A.U.; each cell contains sixteen S_8 molecules or 128 atoms. This form is very stable at ordinary temperature.

Of the several varieties of monoclinic sulphur, as described by Groth, the needle-shaped crystal is the most common type. It is reported that it is unstable below 105°C. but quite stable above this temperature; milk of sulphur and the gummy deposit of colloidal sulphur which are insoluble in CS_2 and which were regarded as amorphous, are really crystalline. Their X-ray diffraction patterns clearly indicate that they have the same structure as $S\alpha$. Plastic sulphur when prepared by pouring boiling sulphur in cold water is amorphous producing only one diffuse band.* This plastic mass soon transforms into a hard crystalline solid consisting of two portions—(*a*) One soluble and (*b*) the other insoluble in CS_2. The insoluble part, as revealed by its X-ray pattern, is a new allotrope of sulphur. It has been termed $S\omega$. White sulphur, obtained by the hydrolysis of S_2Cl_2, hitherto supposed to be amorphous also exhibits $S\omega$ structure. The sublimate of sulphur shows the presence of this new variety.

While solid blocks of sulphur, prepared from the liquid kept at a temperature lying near the melting point, are yellow like ordinary roll sulphur, those at temperature in the neighbourhood of the boiling point freeze into a chocolate brown mass. At intermediate temperatures are obtained solids of all shades of colours passing from bright yellow to chocolate brown. The percentage as well as the stability of the insoluble portion ($S\omega$) in this chilled mass also depends upon the initial temperature of the liquid sulphur. Both the percentage and the stability of $S\omega$ are small when it is obtained by chilling liquid sulphur just near its melting point. They at first increase with the temperature of liquid sulphur, reaches a maximum and then falls again to a very low value. $S\omega$, thus prepared, is transformed into soluble $S\alpha$ with a rate increasing with temperature. Near about 30°C., however, specimens of $S\omega$ retain their insolubility in CS_2 even after its complete conversion into $S\alpha$. The application of a chemical like NH_4OH makes insoluble $S\omega$ soluble and at the same time converting it to $S\alpha$.

The insolubility of $S\omega$ has for many reasons been attributed to the presence of SO_2, perhaps on the surface of sulphur crystals. The sample becomes easily soluble when this absorbed SO_2 is removed. The presence of SO_2 in $S\omega$ can be demonstrated by shaking crystals of this variety with a solution of $KMnO_4$ when the latter becomes colourless. The presence of SO_2 is, however, no guarantee for the stability of $S\omega$; for at low temperature $S\omega$ can still retain its insolubility while changing into $S\alpha$. Blatchford[28] has found that the Bragg spacings, i.e. '*d*'

* If this plastic mass is stretched to 8 to 10 times its original length, spots appear on the plate showing that a part of it has been transformed into a crystalline variety and its axial length is different from that of $S\alpha$.

value of liquid sulphur suddenly changes at a temperature where similar changes in viscosity, density and colour are noticed. The temperature at which these changes occur is, according to our observations, related to the high percentage of Sω. The structure of the latter is probably hexagonal and, in this form it is more conducting than the stabler variety Sα. The possibility of such a structure may also be guessed from the fact that each of the other elements of the same group, viz. O, Se and Te has a stable hexagonal allotrope; perhaps, this is one of the reasons why in practice the best type of sulphur insulators is prepared from liquid sulphur just above its melting point, where from our experiments, the percentage of Sω is almost nil.

The critical temperature of the enantiotropic transformation S$\alpha \rightleftarrows$Sβ has been reported to be 96°·5C. But results of careful investigations on the transition of S$\alpha \rightarrow$Sβ have failed to detect any such transformation between 96°·5C. and its melting point. The difficulty of determining this critical temperature by single crystal method is that the crystal breaks up above 96°·5C., while in the powder photograph method, growth of size of particles takes place producing random spots and streaks which make any direct conclusion about such a transformation almost impossible. In order to avoid these difficulties, a thin celluloid film containing finely powdered sulphur is prepared. This specimen of sulphur embedded in celluloid has been examined at different temperatures up to its melting point. The pattern is always found to be that of pure Sα. These experiments lead to the conclusion that Sβ can be prepared from molten sulphur (Groth, *l.c.*) and is not produced below the melting point.

Allotropes of the element selenium are known as (1) Black vitreous selenium, prepared by chilling molten selenium, (2) Monoclinic selenium prepared by evaporating to dryness the dissolved part of black vitreous selenium in CS_2, and (3) Hexagonal selenium, the stablest variety. Both monoclinic and vitreous selenium pass into the hexagonal form when heated for a sufficient time at a temperature below its melting point.

Study of these allotropes by the X-ray diffraction method and also of liquid and colloidal selenium has been made in this Laboratory. Prins and Dekeyser [29], however, observed that at 73°C. under tension, vitreous selenium crystallizes; but we have found that it also converts itself into the crystalline form even at so low a temperature as 27°C. without any tension. Of course the higher the temperature, less is the time required for complete conversion. This process of devitrification has been studied in detail by the powder method of analysis. Ordinary vitreous selenium gives three broad bands but when the percentage of the transformed crystalline product in vitreous mass becomes appreciable, sharp lines are superimposed on these bands. This is known as line-band correspondence. At 100°C. one hour is required for the complete conversion of vitreous selenium into the crystalline form, at 55°C., 6 hours, at 38°C. more than 1100 hours and at 27°C. several years are necessary for such a transformation to be completed. In this connection, our thanks are due to Dr. Grippenberg of Masaby, Finland, who supplied us with a stick of vitreous selenium kept at 27°C. in his laboratory for 7 years. On X-ray examination, the surface of the stick, just after its arrival in Calcutta, was found to be completely converted into the monoclinic form although its interior portion was still amorphous. It is interesting to note that at low temperatures such as 27°C. after sufficient time, vitreous selenium converts itself into the monoclinic while above 43°C., only into the hexagonal form and at intermediate temperatures such as 38°C., 40°C., etc., both these varieties are found to be present in the transformed product.

The monoclinic variety also converts itself into the hexagonal form. At 120°C. one hour is required for the transformation, at 80°C. 15 days and at 65°C. more than 17 days are required for a complete conversion of monoclinic Se into the hexagonal form.

Tellurium is placed in the same period as sulphur and selenium in the sixth group. But unlike sulphur and selenium, the allotropism of tellurium is much less marked. Tellurium is known to exist in two forms, one is crystalline (hexagonal) while the other is amorphous. Amorphous tellurium is a brownish black powder usually obtained by precipitation method, e.g. by reducing a solution of tellurium dioxide with sulphurous acid. It easily transforms itself into the crystalline variety with the application of heat. The density of tellurium is curiously variable and said to change under the influence of heat; this is attributed to the presence of two dynamical allotropes in ordinary tellurium; the density as well as other properties depends on their relative proportions. This view, however, is contradicted by Damiens [30] who contends that impurities only cause all these inconsistencies.

Like density, specific heat is also variable, and the X-ray exposure is said to increase it by 8%.

Precipitated tellurium so long supposed to be amorphous is found, on X-ray analysis, to be crystalline and it has the same structure as the metallic tellurium—the only difference being that crystals in the former mass are in a finely divided state. Other chemical methods of preparing the so-called amorphous variety were also tried but no existence of the latter could be detected by X-ray diffraction method, even when the preparation and exposure were carried out at 0°C.

The diffraction pattern of tellurium at different temperatures resulted in the rejection of the hypothesis of two allotropes of tellurium as patterns obtained were always the same. The change of specific heat by X-ray exposure has been attributed to a change in crystal structure; but the pattern obtained with cells changed every half an hour shows no difference from that of a cell exposed continuously to X-rays for 24 hours. Therefore, either X-ray has very little effect on the crystal structure of tellurium or its effect on such transformation must be instantaneous and such a possibility appears very unlikely.

Tellurium cannot be prepared in the vitreous state by ordinary chilling method and in this respect it differs from sulphur and selenium.

An amorphous variety of tellurium can, however, only be prepared by precipitating a fresh colloidal solution of tellurium by an electrolyte. The coagulum yields a band on X-ray exposure. The electrolytic coagulum from an aged sol is, however, crystalline and its pattern is found to be different from that of the ordinary variety. This has been attributed to a new allotropic modification of tellurium. This form is again unstable and is turned into hexagonal Te by a slight heat.

Both amorphous and liquid sulphur show only one broad diffraction band of spacings $d = 3{\cdot}5$ A.U. and $d = 3{\cdot}6$ A.U. (128°C.) respectively. In amorphous selenium (colloidal), we have three broad bands of which the first one ($d = 3{\cdot}80$ A.U.) is very intense. Liquid selenium shows one diffraction band at $d = 4{\cdot}04$ A.U. (217°C.). In tellurium, bands from amorphous and liquid states correspond to each other having $d = 3{\cdot}09$ A.U. and 3·11 A.U. (450°C.) respectively.

After making proper temperature correction for the coefficient of expansion in all these elements, we notice one peculiarity, viz. the approximate coincidence between the values of Bragg spacings obtained both in liquid and in amorphous state is really striking. It has been mentioned before that the amorphous bands are found in positions where strong groups of rings appear from powdered crystals. These are not only the peculiarities of S, Se and Te but also of other substances such as Carbon, Phosphorus (Randall)[31]. These considerations lead one to suggest that so called amorphous substances may really consist of minute crystals too small to show any clear sharp ring. Our experiments merely suggest that the same sort of arrangement as found in amorphous substances may still persist in liquid state. Similar coincidence between the liquid band with the corresponding crystal lines in the case of alkali metals, lead, etc., by Randall (*l.c.*) and others points to the same conclusion. Prins[32] has, however, shown from theoretical considerations that the pattern to be expected from any liquid depends on the crystalline structure of the corresponding solid and that the distinction between the minute crystalline solid and the liquid is one of degree and not of kind. Amorphous substances may be taken as an intermediate state between the above two states. Ordinarily, amorphous substances are prepared by suddenly chilling the liquid and we can only guess the possible similarity of diffraction bands from these two states in the following manner. Through the preponderance of the heat motion, the regular arrangement of atom in the crystal is completely lost but at the same time any atom due to this heat motion cannot be thought of as to have completely overcome the interatomic force and move about as 'freely' as in a gas in the liquid medium and some influence of direct neighbours is still retained in liquid state, as a result, any atom with some of its neighbours forms a small group, the nature of which again depends on their relative positions in the solid state. These groups are not stable but are continuously being formed and broken in liquid and, on an average, its size will depend on the temperature. Thus if the latter is high the size of the group will be evidently small and the corresponding Bragg spacing will be large. This is in accordance with experimental results on S, Se and also on other liquids. Now if the liquid is suddenly chilled, the extra heat energy possessed by the atoms which destroyed their regular arrangement in the crystal, is lost and the mutual interatomic forces being strong, they at once come into play converting these small groups in the liquid into solid and thus they are found to be distributed at random in this (solid) state. The diffraction pattern from these solid groups will now show great similarity with that found for the liquid. If the transformed mass is now kept at the room temperature for a long time, the mutual force between neighbouring atoms and also the heat motion will help to bind the groups into a stabler form, i.e. into a big crystal. Among other considerations, in non-polar crystals, the time taken to completely devitrify the mass will depend on the strength of the interatomic force and also on the energy of atoms due to heat motion only, at that temperature. Sometimes a slight heat rapidly devitrifies the amorphous mass (as in non-conducting substances). From these considerations, an important conclusion can be drawn—(*a*) smaller groups may gradually be made bigger by heat but not *vice versa*. Experiments on S, Se and Te show this effect very clearly. As an example, amorphous selenium of different sizes (or small crystals or groups) can be prepared by different methods and actually it is found that the sample which has a large Bragg spacing can be converted by slight heat to that variety where the corresponding '*d*' value is small but not *vice versa*. Again if a sample of red precipitated selenium having the largest '*d*' value is heated at constant temperature (36°–38°C.) for a long time, not only the corresponding Bragg spacing but also breadth of the band decreases gradually and after some time the sharp lines, as found from crystalline variety, appear. This experiment is in accordance with the suggestion mentioned above for the proper understanding of the liquid and solid state though at the present moment it appears to be crude and speculative.

Earlier works on metal sols such as gold and silver have clearly shown that these small particles are really crystalline (size is of the order of 10^{-5} cm. in each direction) but our experiments on non-conducting or semi-conducting colloidal particles like S, Se and Te have shown that these particles may be crystalline or amorphous depending on conditions of precipitation. Sulphur sols whether precipitated by a suitable electrolyte or held in suspension in water, show sharp X-ray pattern but these diffraction lines are a bit broader than those of ordinary crystals suggesting that the size of the particles is of the order of 10^{-5} cm. or less. If the sols are prepared and precipitated at a low temperature (0°C.) it is found to be $S\omega$, while at room or higher temperature, it is purely $S\alpha$.

Selenium sols were prepared in the usual way in the laboratory. It is found that the coagulum formed spontaneously during ageing is amorphous, while precipitates obtained by rapid and also by 'very' slow coagulation (about 15 days) by the addition of suitable electrolytes, are amorphous and monoclinic respectively. In order to notice any change which might be effected inside the mass of the colloidal particles the sol was taken in a sealed glass tube and was heated for several hours at 100°C. Selenium precipitates thus obtained from rapid and slow coagulation are found to be amorphous and hexagonal respectively; but gummy colloidal selenium, obtained by evaporating both heated and unheated sols at room temperature, produces on X-ray analysis one broad band agreeing very nearly with that found for liquid selenium at 0°C. Unlike selenium, tellurium sol is very stable and does not produce any natural precipitate even on long standing. Precipitates obtained from freshly prepared and heated tellurium sols (as in slenium sol) are respectively amorphous and hexagonal. Coagulum from heated sol is always hexagonal while that from the simple aged sol shows two diffuse rings (bands) in the place of the diffuse band observed for the amorphous variety; but the thin film that settles over the concentrated sol and obtained on allowing it to dry up in a basin, is purely crystalline and its pattern (as shown by the position and the intensity of the lines) is found to be quite different from that of the hexagonal type; at the same time the dried up mass obtained by evaporation at ordinary temperature is gummy and produces rings and bands showing a close resemblance to the new variety.

A general picture can now be formed explaining the different forms of these elements in which they are observed to occur under different conditions of precipitation.

In a freshly prepared sol, the individual colloidal particles may not be single crystals but may consist of still smaller crystallites. The crystalline nature of these crystallites should be determined by the energy consideration prevailing in that fine state of matter; these crystallites may retain a structure similar to that of the stable variety (ordinary variety at room temperature) or a new allotropic variety or a mixture of both—all depending upon the energy conditions of their formation at that state.

On heating the sol, two effects may be expected; firstly, several individual colloidal particles tend to become one single crystal due to the greater freedom of the atoms for rearrangement; secondly, due to greater thermal energy, the particles collide in spite of their charges and grow in size which may ultimately cause precipitation. Further, if the charges are due to adsorption of ions by the particles, as is held by one school, the heating may also lead to a partial removal of charge due to the escape of adsorbed ions. On adding an electrolyte, the dielectric constant is increased thereby decreasing the repulsive force between similarly charged particles; besides, the charge of the colloidal particles is neutralized by oppositely charged ions of the added electrolyte and so coagulation begins.

X-ray diffraction pattern of the precipitate consists of a single band, approximately in the position of a group of rings of the stable variety. This clearly indicates that the size of the single crystal particle present in fresh sol must be of the order of 10^{-6} cm. or less (particles lying between 10^{-3} to 10^{-5} cm. yield sharp line pattern). On adding the electrolyte, the agglomeration of the colloidal particles occurs so rapidly that they settle down (under gravity) before the crystallites can orient themselves to form bigger crystals. In other words, during the actual process of rapid coagulation of tellurium and selenium sol, the sizes of the single crystallite present in the colloidal particles do not increase appreciably.

On heating the sol, each colloidal particle becomes a single crystal. It may grow in size. The precipitate thus yields sharp continuous rings characteristic of the hexagonal variety. Supposing now that in this case, process of electrolytic coagulation does not influence the size of the crystallites to any great extent, the particle size of the precipitate gives a rough idea of the size of the particles originally present in the sol. This is not unlikely, for the colloidal sol may contain particles big enough to be of the order of 10^{-5} and be still stable and particles of this order are able to produce sharp continuous ring pattern.

Colloidal solutions (viz., sulphur, selenium, etc.) are found to coagulate (at least appreciable percentage of it) on heating, the reason probably is that the colloidal particles have grown too large to remain in suspension. In the case of tellurium we are led to the conclusion that the particle size grows on heating but only to the order of 10^{-5} cm. so that they are still able to remain in suspension. An alternative explanation may also be suggested. In fresh sol where the individual colloidal particles consist of crystallites distributed at random when the coagulation is occurring, the tendency of crystal growth is not sufficient to cause an increase in the size of the crystallites to an appreciable extent; but in the case of heated sol, the individual particles being single crystals, the tendency of crystal growth is perhaps larger so that during coagulation, the increase in crystal size by orientation of the smaller crystallites is possible, resulting in the presence of crystals of sizes 10^{-5} to 10^{-3} cm. in the coagulum. As the sol is heated and kept for a considerable period at a temperature much higher than the room temperature, it is likely that any other form of tellurium or selenium (which might be present) should be converted into the ordinary metallic variety and in the coagulum only the hexagonal variety can be expected.

The pattern of this precipitate from the heated sol also shows that the added electrolyte has no effect on the pattern due to the precipitate although it may quite justly be suspected of containing a portion of the latter.

As the size of colloidal particles grows or crystallites in those particles increase in size, there may be intermediate stages where other unstable allotropes may exist before they finally reach the most stable variety. Such unstable allotropic modifications can be detected only under certain characteristic conditions. Thus it has been observed that S_ω is formed before colloidal particles are finally transformed into the orthorhombic variety. Monoclinic selenium is found to exist before it passes to the more stable hexagonal modification and before the hexagonal tellurium variety is reached, a new form of tellurium is found whose structure is not yet definitely known (perhaps monoclinic). The stability of these unstable allotropic modifications, however, depends, among other factors, mainly on the temperature at which they are prepared.

The state of colloidal particles in general has for a long time been an unsolved problem both to physicists and chemists. A systematic investigation carried over a large number of sols by X-ray or electron diffraction method is expected to throw some light on the true nature of the colloidal particles and their properties, a thorough knowledge of which is essential for a proper understanding of the relation between the solid and the liquid state of matter in general.

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SECTION OF CHEMISTRY

President:—M. QURESHI, M.Sc., Ph.D., F.N.I.

Presidential Address

(*Delivered on Jan. 4, 1942*)

CERTAIN ASPECTS OF PURE AND APPLIED PHOTO-CHEMISTRY.

LADIES AND GENTLEMEN,

I intend discussing certain aspects of pure and applied photo-chemistry, mainly with the idea of focusing attention on the importance which the subject of photo-chemistry has acquired in recent years in the fields of pure and applied research. But before doing that, I seek your indulgence for a few general remarks on the question of the relative importance of pure and applied research—a question, which has been brought to the fore by the growing demand for an increasing emphasis on the applied side of science.

PURE AND APPLIED RESEARCH.

There can be no two opinions as to the fundamental importance of research in pure science. We cannot have applied science without first having science; and science cannot develop without disinterested and independent research, conducted with a spirit of free inquiry by men whose sole aim is the pursuit of truth for the sake of truth. Therefore, if we wish to see our country taking its due share in the development of science and the creation of new knowledge, instead of simply copying its applications, we should, on no account, permit any restriction on pure research. On the contrary, we must do everything in our power to extend it and encourage those who are engaged in it. But it is one thing to put forward one's own claims and quite a different thing to refuse to recognize the claims of others. The advocacy of pure research should not lead us to ignore the important position occupied by applied research in the present-day world, not only from the point of view of its utility to society but also from the point of view of the part played by it in the advancement of pure science. I am afraid this second point is very often missed by those who look down upon applied research for its purely utilitarian motives. The history of the development of our science shows that investigations originally designed to achieve immediate commercial objectives have often led to important advances in pure science. The efforts of the old alchemists to transmute a base metal into gold affords a good example of how a purely utilitarian motive can lead to an advance in our knowledge. The discoveries made by these alchemists in the course of their search for the Philosopher's stone and the Elixir of life are too well known to need repetition. Coming to the period of modern science, this inter-dependence of pure and applied research becomes increasingly great, so much so that it is now difficult, if not impossible, to draw a line between the two, particularly in the fields of physics and chemistry. The researches conducted by Black in 1756 on latent heat enabled James Watt in 1782 to construct his steam engine. The new steam engine created a demand for the construction of heavy machinery which led to the development of the iron industry and the development of the iron industry in its turn created the new science of metallurgy. The discoveries of Schultze (1727) and Scheele (1777) on the photo-sensitivity of silver compounds enabled Daguerre and Niepce (1838), Maddox (1871) and Bennett (1878) to develop the art of photography and the photographic plate, developed as a result of applied research, has been instrumental in many scientific discoveries, including Röntgen's discovery of X-rays. It is often said that the development of photography in the second half of the 19th century tended to delay the scientific development of photochemistry, but it is forgotten that it was Vogel's discovery of the sensitization of photographic plates by the addition of certain dyes that paved the way for theoretical advance in photosensitization.

Many such instances could be cited to show the interdependence of pure and applied science, and the advantages to both society and science resulting from a proper co-ordination of the two. Some of the important advances in physics and chemistry which have taken place in recent years in Europe and America are the direct results of the close co-operation between fundamental and industrial research. I need only refer to the results achieved by the research laboratory of the General Electric Company of America during the last forty years of its existence. The work carried out by Coolidge, Langmuir, Dushman, Hull and others in this laboratory has resulted in new developments in the electrical art and industry on the one hand and in fresh advances in our knowledge of the natural phenomena, on the other. Langmuir's work on the adsorption and reaction of gases at surfaces made us understand many of the phenomena of colloidal chemistry, heterogeneous catalysis, surface tension and thermionic emission. On the practical side, it resulted in the invention of gas-filled lamps and improved radio-tubes. The problems arising out of these technical developments led to further work of fundamental importance on surfaces, which has not only resulted in a knowledge of the mechanism of the lubrication of metal surfaces and the structure of films, but has also opened up new fields in the study of biological reactions at membrane surfaces and cell boundaries in living organisms.

If science is to make a rapid progress in this country, we must follow the same course as that adopted by the progressive countries of the West and try to bring about full co-ordination between pure and applied research in our universities, research institutes and industrial laboratories. The establishment of a Central Board of Scientific and Industrial Research by the Government of India is a step in this direction which has been taken at the right moment. If similar organizations are set up in the provinces and Indian States and worked on right lines, we might see the beginning of a new era in the scientific and industrial development of our country, which may ultimately lead to national well-being and strength. But the success attending such efforts will depend to a large extent on the amount of money which the Government and the Industry are prepared to spend on the financing of research. The amount of money which India is at present spending on fundamental and industrial research is negligible compared with the amount spent by other countries. According to the latest survey of industrial research carried out by the National Research Council of America, American industry alone employs more than 70,000 researchers in over 2,200 laboratories, at an estimated cost of three hundred million dollars. We shall be satisfied with much less, but we know that it is well nigh impossible to get it. Perhaps, it is not yet fully realized in our country that every rupee invested in research will be paid back a hundred-fold in the shape of the increased prosperity of the whole country. If the rich are to be taxed for the sake of feeding the poor, the best way of utilizing the money raised through such taxes is, in my opinion, to spend it on the promotion of scientific and industrial research, because the money so employed will ultimately go to the pockets of the poor.

After these preliminary remarks, I shall now proceed to the main theme of my address. In doing so, I shall first give a brief summary of the present day ideas about the process of light absorption which proceeds a photo-chemical change, then refer to the secondary effects which follow the primary act of light absorption, and finally review the progress made in the study of some photo-chemical reactions which are important from the technical point of view.

The Primary act of light absorption.

Strictly speaking, the photo-chemist is concerned only with the chemical changes taking place as a result of the interaction between matter and radiant energy. But since these changes are the direct results of the absorption of radiant energy by the system, a proper understanding of the primary act of light absorption and other physical changes connected with this act is essential to the correct interpretation of photochemical changes which follow it. Thanks to the work carried out by physicists during the last thirty years on absorption spectra and their interpretation on the basis of the Quantum theory, we are now in a position to form a more or less clear picture of the elementary act in the process of light absorption.

Taking first a system composed of atoms, the absorption of a quantum of sufficient radiant energy ($h\nu$) by an atom is supposed to raise an electron from a lower energy level to a higher energy level, thus producing what is known as an *excited* state, which lasts for about 10^{-8} second. If nothing happens to the atom in the meanwhile, the electron returns to the ground level or some other excited level of low energy and the absorbed energy is re-emitted as *resonance* or *fluorescence* radiation. The absorption of a quantum of greater energy can lead to *ionization*, in which case the electron leaves the parent atom, having sufficient energy to move out of its field. Thus, in the case of the mercury atoms the absorption of radiant energy at 2536·7 Å and 1849·6 Å leads to resonance, while the absorption of radiant energy at 1187·96 Å leads to ionization. The energy in excess of the ionization energy serves to increase the kinetic energy of the ion and the electron which makes itself manifest in continuous absorption in the region beyond 1187·96 Å on the short wave side. The re-emission of absorbed energy as fluorescence takes place at low pressure and in the absence of other gases. At high pressures and in the presence of a foreign gas, collisions between the excited atoms and other atoms or molecules present in the system may lead to other possibilities. The excited atom may dissipate its energy in the form of heat; it may enter into direct chemical action; or it may transfer its absorbed energy to another atom or molecule which does not absorb directly in that region. All the three possibilities are known to occur, the last one being known as *photo-sensitization*.

The process of absorption of light by an atom or ion in a crystal is somewhat similar to that of a gaseous atom. Here, too, the act of absorption of a quantum of light may either raise an electron to an excited state or remove it from the original atom, depending upon the amount of energy contained in the quantum. If the electron is raised to an excited state, it may fall back to its ground state and the absorbed energy may be re-emitted as heat or fluorescence radiation after a time interval of about 10^{-8} second. If the electron is freed from the parent atom, it will move through the crystal and contribute to its photo-conductivity, until it is trapped at one of the bound energy levels that exist at surface or near cracks in the crystal lattice. The trapped electron may not, however, remain indefinitely there. If it does not produce a photo-chemical reaction [1], it may be released after a certain time and go back to a positive ion or a positive hole and give up its absorbed energy as heat or in the form of radiation. The latter phenomenon is known as *phosphorescence* which takes place with a time-lag between emission and absorption.

The primary act of absorption in the case of a molecule is complicated by the existence in the latter of three different kinds of internal energy, viz., electronic, vibrational and rotational, all of which are capable of being quantized by suitable radiations. The absorption of a quantum of light in the far infra-red produces changes in the rotational energy alone; absorption in the near infra-red affects both the vibrational and rotational energy; while absorption in the visible and ultraviolet region is accompanied by a simultaneous change in the electronic, vibrational and rotational energy. The last-named spectrum consists of several band systems, each system consisting of a series of bands and each band consisting of a series of fine lines, converging to a definite limit, the head of the particular band. The general position of a band system corresponds to a given state of electronic excitation; the separate bands of a system are due to a whole series of vibrational excitations, connected with each electronic state; and the fine lines in each band are determined by a number of rotational states corresponding to each vibrational state of the molecule. Some times, the band system is followed on the short wave side by a continuous absorption, showing the complete absence of vibrational and rotational states. This indicates that the molecule absorbing in this region is split up into atoms. A comparison of the spectroscopic data with the thermo-chemical heats of dissociation shows that homopolar diatomic molecules, such as the halogens and hydrogen, are split up into one normal atom and one atom in the excited state. In some cases, it happens that before the region of continuous absorption is reached, the rotational fine structure disappears, although the bands themselves remain distinct. The appearance of this diffuse structureless band spectrum, named by its discoverer (Henri) 'predissociation spectrum', is taken to indicate that the excited molecule produced by absorption in this region undergoes, through a redistribution of its several forms of excitation energy, a radiationless transfer to another state in which it dissociates spontaneously. This redistribution of energy takes place during a period which is short compared with the time of rotation but long compared with the time of vibration [2, 3, 4]. On the basis of these interpretations, the primary process of absorption in different regions in the case of a simple molecule may be pictured as follows:

The absorption of light in the region of discrete bands produces an excited or activated molecule, which in the absence of a collision during its life-period of about 10^{-8} sec. gives up its stored energy as fluorescent radiation. The absorption in the region of diffuse bands also produces an excited state, but, through a rearrangement of energies, the first excited state changes over to another state, in which the molecule spontaneously dissociates. The absorption in the continuous region leads directly to dissociation without the production of an intermediate state of activation. This simple picture agrees with actual experience in those cases only where the conditions involved are relatively simple, as for instance, in the case of di-atomic molecules, when they are present in a gaseous system at low pressure. In a gaseous system at high pressure or in the presence of inert gases, dissociation may also occur as a result of collision when the light is absorbed in a band region [5, 6]. This is known as induced predissociation. In the case of complex molecules, the complexity of vibration introduces further complications into the process which render it difficult to predict the exact process of the decomposition of the molecule from a knowledge of the type of absorption spectrum. The results of the recent investigations of Norrish, Noyes, Gorin, Rollefson, Burton, Taylor and others [7, 8, 9, 10, 11] on the photolysis of simple aldehydes and ketones give a clear indication of the difficulties experienced in interpreting the exact process of decomposition occurring in complex molecules on the basis of the absorption spectra alone. In such cases definite conclusions can only be reached by taking into full consideration the nature and amounts of the products of the photo-chemical reaction along with the characteristics of the absorption spectrum.

Secondary processes.

The primary process in a photo-reaction is, thus, seen to consist in spontaneous photo-dissociation or activation, depending upon the nature of the absorption spectrum and the existence of other factors affecting the field of the absorbing molecule. In the first case, a direct photo-chemical change is involved, but the process need not stop at this primary stage and the products of the primary photo-dissociation may react amongst themselves or with other molecules present in the system to yield different products in varying amounts, according to the conditions prevailing in the system. These so called secondary processes or dark reactions are of particular significance to the photo-chemist, on account of the influence exerted by them on the final outcome of a photo-chemical process. The activated molecule, produced as a first step in the primary act of absorption, can subsequently react in several ways. It may (*a*) dissipate its stored up energy in the form of heat through a collision with another molecule; it may (*b*) re-radiate the whole or part of its energy as fluorescence; it may (*c*) transmit its excess energy to another molecule and act as a photo-sensitizer; and finally it may (*d*) enter into chemical reaction with a normal molecule. The occurrence of any one of these possibilities depends upon the state of excitation, the nature of other molecular species present in the system, and their mutual affinities. If a chemical reaction occurs as a secondary process, its kinetics are determined by the same factors which determine the kinetics of an ordinary dark reaction, namely concentration, temperature and the presence of catalysts.

If we confine ourselves to the primary process, it is apparent that the quantum yield, or the number of molecules dissociated or activated for each quantum of radiation or photon absorbed, should be unity as required by the law of photo-chemical equivalence enunciated by Stark and Einstein, provided the free radicals or atoms formed on dissociation do not immediately recombine. Such a recombination, if it occurs, will make the primary quantum yield less than unity. Franck and Rabinowitch [12], have emphasized the increased probability of the occurrence of this effect, which they call 'primary-recombination', in solution, where the solvent molecules may prevent the escape of the dissociating partners from each other and thus bring about their recombination with loss of energy to the solvent. For the total reaction, the quantum yield may vary within wide limits on account of the secondary effects. The dissipation of energy as heat or the occurrence of a reverse reaction can make the overall quantum yield less than unity; while the continuation of reaction through a chain mechanism initiated by light can lead to a value considerably greater than unity. The overall quantum yield is, therefore, a measure of the extent to which the total reaction is affected by secondary processes and its determination together with a study of the absorption spectrum provides evidence as to the nature of the primary and secondary processes constituting the reaction mechanism. Further useful information concerning reaction mechanism is obtained when the overall quantum yield is determined under different conditions, resulting from a change in concentration, light intensity, wavelength, temperature, and the nature of the surface of the reaction vessel. The photo-combination of chlorine and hydrogen and the photo-dissociation of ammonia afford good examples of the application of these methods to the problem of elucidating the mechanism of photo-chemical reactions.

Photography.

The greatest achievement of applied photo-chemistry is the modern art of photography. The development of this art during a period covering about one century has not only led to the creation of a big industry for the manufacture of photographic materials, but has also been responsible for progress in other allied industries such as the manufacture of intermediates, dyestuffs and optical instruments. At the same time, it has stimulated theoretical researches on the fundamental problems involved in photographic processes, which are bearing fruit in a clearer understanding of these processes and the consequent rationalization of the industry. It is not possible here to cover the whole field of this branch of applied photo-chemistry. I shall deal with only a few important theoretical and practical advances.

The fundamental process in photography is the photolysis of silver halide, accompanied by a visible or invisible change, the latter resulting in the formation of a latent image which can be developed subsequently. The visible change consists of a sequence of colour changes, varying from lilac to violet and slate grey in the case of silver chloride. At the same time chlorine is liberated. These colour changes were at first attributed to the formation of a series of sub-halides. Subsequently it was assumed that the coloured substances were solid solutions of a sub-halide of the type Ag_2Cl in silver halide. The present view is that these coloured substances are colloidal solutions of free silver in silver halide. The absorption spectra of silver halides in the pure state and in emulsions have been measured by many workers [13, 14]. In thin layers, micro-crystals of pure silver chloride and silver bromide show absorption limits towards the longer wavelength at 4000 Å and 4800 Å respectively. There is no limit towards the shorter wavelength in the case of silver bromide, absorption and photo-chemical action occurring throughout the whole ultraviolet region and even beyond it. In a photographic emulsion, the absorption of ions on crystals can exert a deforming influence on the crystal faces, leading to a shift in the absorption limits [15]. The spectral sensitivity of a particular emulsion, thus, depends upon the mode of its preparation. The normal range of spectral sensitivity of an ordinary unsensitized plate is 5000–2200 Å.

As early as 1840, Becquerel had discovered that silver halide papers could be made sensitive to the yellow and even to the red region through long exposures. Lüppo-Cramer showed that this was due to the sensitizing action of colloidal silver and he succeeded in reproducing the phenomenon by adding colloidal silver to silver chloride [16]. In 1872 Vogel discovered that the treatment of emulsion with certain dyestuffs made the plate sensitive to green and yellow light. This discovery represents a great landmark in the history of the development of photo-chemistry. It revealed the existence of an effect known as optical sensitization, which has been the subject of a good deal of theoretical study and research. On the practical side, it led to ortho-chromatic and pan-chromatic plates and the extension of photography, during recent years, into the infra-red region as far as 13560 Å. The first dye used by Vogel to sensitize the plate was Coralin. Later on, other dyes were found effective for one region or the other. The search for new sensitizing dyes led to investigations on the relation between the constitution of dyes and their spectral range of absorption in solution, as a result of which much useful information has been obtained and applied to the synthesis of new dyes and intermediates. The number of the known dyestuffs is very large, but of these only a small proportion are effective sensitizers. Although much attention has been devoted to this problem during recent years, the connection between the chemical constitution of a dye and its power to sensitize is not yet quite clear. Most of the dyes used as sensitizers at present belong to polymethine group and many of them are cyanine dyes. The amount of the dye required for sensitizing purposes is very small, a dilution of one in 400,000 being sufficient in some cases. Mention may also be made of the super-sensitizing dye combinations patented by Kodak Co., and Agfa, in which one dye enhances the activity of the other. It has been further discovered that substances which, in themselves, are not sensitizers can increase the sensitizing power of a dye.

The increased spectral sensitivity imparted to the plate by sensitizers made it difficult to develop the plate in a dark room in red light. This difficulty has been removed by the discovery of the de-sensitizing action of certain dyestuffs on the exposed plate. In 1920, Lüppo-Cramer found that phenosafranine used in or before the development bath decreased the sensitivity of the exposed plate without affecting the latent image. Since then, many de-sensitizers have been described and have found practical application. It has now been recognized that nearly all sensitizers can act as de-sensitizers under certain conditions. The same dyes, which act as sensitizers in small concentrations, show de-sensitizing action when used in larger concentrations [17], it may, however, be pointed out that all de-sensitizers are not optical sensitizers, because de-sensitizing action is also exhibited by colourless compounds. The effect of these developments on the practice of photography is remarkable. Previous to the discovery of sensitizers for infra-red and de-sensitizers, plates could only be exposed in sufficiently strong light and developed in a dark room. Now it is possible to expose the plate in the dark and develop it in a strong light.

On the theoretical side, the nature of the latent image and the mechanism of its formation have received a good deal of attention during recent years. As a result of the work carried out by several investigators on single crystals of silver halides and on photographic emulsions, it is now clear that the latent image particles are identical with those produced by the action of light in single crystals and consist of silver atoms, formed according to the law of Photo-chemical Equivalence, [18, 19, 20, 21, 22]. With regard to the mechanism of the latent image formation, the theory recently put forward by Gurney and Mott [23] accounts for the known facts in a satisfactory way. According to this theory, which has now received general acceptance, the primary act of absorption consists in the raising of electrons to higher conduction levels in which they are free to move in the crystal lattice and give rise to photo-conductance. When these electrons drop to lower conduction levels, which are assumed to exist in silver or silver sulphide present in the sensitivity nuclei, they are trapped, thereby imparting negative charge to the nuclei. The potential gradient, thus set up, causes mobile silver ions to collect around the sensitivity nuclei and form into a small clump of silver atoms, after being electrically discharged. This concentration speck constitutes the latent image. On development, electrons derived from the developing agent adsorbed on the silver nucleus cause the further attraction and discharge of silver ions. The theory gives a satisfactory explanation of several phenomena, such as high intensity and low intensity reciprocity failure and Herschel's effect. Further support is lent to it by the work of Webb and Evans, Berg and Mendelsohn, and Berg on the latent image formation at low temperatures [24, 25, 26].

The process taking place in a sensitized emulsion is similar to the one just described except with regard to the origin of the electron. While in an unsensitized emulsion the electron originates from silver halide, in a sensitized emulsion it is supposed to originate from the dye molecule. This explains the relatively small amount of energy required for releasing an electron in a sensitized emulsion, because, in this case the original level from which an electron is raised is higher than the original level in an unsensitized emulsion. There is, however, one experimental result which lacks satisfactory explanation. According to the theory, the number of silver atoms formed on exposure should be equal to the number of dye molecules. But the number of silver atoms actually found present after exposure is many times greater than the number of adsorbed dye molecules [27, 28, 29]. Several explanations have been suggested for the excess of dye molecules over silver atoms, but none of them is quite satisfactory.

PHOTO-HALOGENATION.

The introduction of halogens into organic compounds under the influence of light is a process of considerable theoretical and practical importance. The technical applications of photo-halogenation are covered by a large number of patents, but of these only a few have so far been exploited on a commercial scale. Leiser and Ziffer [30] describe a method for the chlorination of methane in which the main product is methyl chloride. A mixture of methane and chlorine in the proportion of one to six by volume is passed through cooled chambers and exposed to the light from a mercury arc. Small quantities of hydrogen chloride and water are introduced into the system, as these are found to prevent the formation of products other than methyl chloride. The efficiency of the reaction is claimed to be 85% calculated on the basis of methyl chloride. Payne and Montgomery [31] describe a method, which is a combination of catalytic and photo-chlorination. The catalyst is prepared by passing chlorine through a hydrocarbon oil mixed with powdered coal at about 150°C. until hydrochloric acid ceases to be evolved and the product assumes the form of a porous black solid. A mixture of methane and chlorine in the proportion of one to three, containing some moisture, is, then, passed over the catalyst in a reaction chamber maintained at about 150°C. The products of the reaction are subsequently led through silica tubes exposed to the light from a mercury lamp. Snelling [32], claims to bring about more efficient photo-chlorination of hydrocarbons by passing the mixture of gases backward and forward between transparent baffle plates. The object of the baffle plates is to produce a variation in light intensity which serves to control reactions. The method can also be used in the case of liquid hydrocarbons. Lacy [33] obtains chloroform by exposing methylene chloride, water and chlorine to ultraviolet light.

The chlorination and bromination of aromatic hydrocarbon with side chains under the influence light results in the formation of a mixture of substances with the halogen in the side chain and nucleus. It should, however, be possible to vary the conditions with regard to light intensity, frequency and concentration in such a way that the product obtained is more or less pure. Geiger and Gibbs [34] find that a mixture of chlorine and toluene vapour, under the influence of ultraviolet rays, reacts to yield products chlorinated in the side chain. Ellis [35] has described a process for the manufacture of benzyl chloride in which a mixture of toluene vapour and chlorine is continuously circulated under gradually increasing temperature conditions and in the presence of ultraviolet light.

The use of sulphuryl chloride as a chlorinating agent has been greatly extended through the recent discovery by Kharash and Brown [36] of the catalytic action of organic peroxides in the chlorination of hydrocarbons. These authors find that, in the presence of small quantities of benzoyl peroxide, sulphuryl chloride is capable of chlorinating in the dark both aliphatic and aromatic hydrocarbons far more readily and smoothly than is possible by the use of light. The method is of special value in the chlorination of the side chains of aromatic hydrocarbons. While the photo-chemical chlorination of such compounds generally yields a mixture, the use of sulphuryl chloride and benzoyl peroxide results in some cases in the production of a pure product containing halogen in the side chain only. Toluene gives a 100% yield of benzyl chloride in 15 minutes and no nucleur chlorination occurs with *m*-xylene. The mechanism of the reaction, according to the authors, consists in the decomposition of the peroxide at the reaction temperature with the formation of free radicals, which initiate a chain reaction involving chlorine atoms. The chlorination of hydrocarbons with sulphuryl chloride in the presence of light has received but little attention. Kharash and Brown (*ibid.*) find that a mixture of sulphuryl chloride and cyclohexane, illuminated with the light from a 300 watt lamp at a distance of 10 cm. and refluxed, reacts no more than 25% in six hours and a mixture of sulphuryl chloride and toluene, similarly illuminated, requires seven hours for the completion of the reaction. No reaction takes place in the dark in either case. Further investigation of these photo-reactions is highly desirable, both from the point of view of the reaction mechanism as well as practical utility. In this connection, reference may also be made to a process patented recently by I. G. Farbenindustrie [37], by which compounds containing sulphur, oxygen and chlorine are obtained by treating paraffins in the liquid phase with chlorine and sulphur dioxide, under short wave illumination. According to another patent of the same firm [38], sulphonyl chlorides of chlorinated hydrocarbons can be prepared by treatment with sulphur dioxide and chlorine at low temperatures in ultraviolet light.

Photo-polymerization.

All unsaturated organic substances, exhibit, in a greater or less degree, the power of combining with themselves to yield polymers. The polymerization reactions of unsaturated hydrocarbons are, however, of special interest, since they form the basis of many important industrial operations, such as, the production of special motor fuels, synthetic resins and rubber substitutes. The tendency to polymerize varies in different compounds and depends upon the nature of the substituents near the double bond. Ethylene, for instance, is relatively stable, but its derivatives containing negative substituents such as, styrene, vinyl chloride, vinyl acetate and acrylic ester, are easily polymerized. Some unsaturated compounds polymerize spontaneously even at room temperature, e.g., formaldehyde, styreme and acrylic ester; others require high temperatures or catalysts. The influence exerted by catalysts is probably connected with their tendency to form complexes. Polymerization can result in the formation of three different types of structure. The first type is a structure of linear growth, called linear polymer, the second type is the ring polymer, and the third type is the crossed-linked polymer. Polymerization of hydrocarbons can follow two different courses, yielding low or high polymers. In some cases both types of reaction occur simultaneously, though perhaps by different mechanisms.

Polymerization is a chain reaction, in which the initiation of the chain can be brought about by light, heat or a catalyst. A study of the kinetics of the reaction gives us information about the mechanism of the three main processes constituting the total reaction, namely chain initiation, chain prolongation, and chain termination. It is believed that, in the case of the linear polymers, chain formation may take place in two ways. The monomers first combine to give dimers, and these dimers subsequently combine to yield a long chain molecule. Alternatively the monomer may be added to the ever-growing chain of the polymer. Since dimerization has been observed with olefines, it is probable that polyolefines are built up by the first process.

Much work has been done in recent years on the polymerization of organic compounds, yielding results of great technical importance. But it must be noted that this work has been confined, for the most part, to the investigation of thermal reactions. Relatively little attention has been given to photo-polymerization which may be expected to yield valuable results both from the practical as well as theoretical point of view. The results obtained from a study of thermal polymerization are not in themselves sufficient to permit the detailed reaction mechanism to be analyzed. The processes responsible for the initiation, propagation and termination of reaction chains are better understood through a study of the photo-chemical reaction where the initiation process is subject to control.

Acetylene, when exposed to the full light of a mercury vapour lamp, is converted to a solid at room temperature [39, 40, 41]. Lind and Livingstone [42] found that the quantum yield of the direct photo-chemical polymerization is about 9. Melville [43], from a study of the mercury sensitized polymerization of acetylene, comes to the conclusion that the excited mercury atoms form a complex with acetylene which adds on other acetylene molecules, thereby producing a polymer by chain mechanism. The length of the chain, which is independent of the pressure and the rate at which chains are started, is about 10 molecules at 20°; but it increases as the temperature is raised, reaching up to 100 molecules at 250°, and thereafter decreases as the temperature is raised still further.

Ethylene is also polymerized when exposed to the full light of a mercury vapour lamp [44]. Its photo-polymerization with mercury vapour as a sensitizer was studied by Oslm and Meyers [45] and Taylor and Hill [46]. According to Mooney and Ludlow [47], both methods of excitation give rise to acetylene as a primary product. It is, therefore, probable that the polymerization reaction is really that of acetylene, which is produced as a result of the primary dissociation of ethylene. The polymer is simultaneously reduced by the hydrogen produced in the primary process. Vinyl chloride and vinyl bromide change into white solid products under the influence of ultraviolet light [48]. When the halogen is replaced by alkyl radicals, the compounds, on irradiation, yield rubber-like products. Vinyl-di-chloride and di-bromide polymerize in light, if they are unsymmetrical. The symmetrical compounds do not show polymerization in light. Vinyl acetate polymerizes to celluloid-like solids, which have received many technical applications [49, 50, 51, 52]. Both heat and light can be used to assist the reaction. Vinyl nitrite polymerizes to a high molecular product in ordinary light [53]. This has not been further investigated. Styrene polymerizes in ultraviolet light to a glass-like resin which, according to Staudinger, may contain up to 6,000 molecules. The length of the chain extends up to 15000 Å, but the diameter does not exceed 15 Å. These polystyrenes possess the greatest molecular weight so far found.

Isopren (mono-methyl divinyl) polymerizes in light to form artificial rubber. According to Staudinger and Leopold [54], the chain of the purified rubber in benzene solution is 5800 Å, the number of carbon atoms is 5,200 and molecular weight 88,000. The thermal polymerization of butadiene has been studied extensively in both the gas and the liquid phase. Photo-polymerization takes place when liquid butadiene is irradiated with short ultraviolet rays from a cadmium arc lamp or a quartz mercury lamp [55]. Gee [56] has studied the photo-polymerization of butadiene at different temperatures and pressures, using mercury vapour as sensitizer. The quantum yield is independent of the pressure. The main product is an insoluble polymer; but a cyclic dimer is also formed by the spontaneous cyclization of the chain dimer.

Photo-chemical reduction of carbon dioxide.

The process of carbon assimilation taking place in living plants under the influence of solar energy, usually called photo-synthesis, is a photo-chemical process of fundamental importance. How this process actually takes place in the laboratory of the green leaf is one of those fascinating problems which have so far defied the ingenuity of scientific workers. The visible products of photo-synthesis are oxygen and starch. The former is emitted by the green leaf and the latter accumulates in the cell. The fact that the ratio of the number of moles of carbon dioxide absorbed to the number of moles of oxygen produced, i.e., the photo-synthetic quotient, has a value very close to unity [57] in the case of a large number of plants of different species, indicates that the primary product of photo-synthesis is a hexose. The equation for the reduction of CO_2 in green plants may, therefore, be written as under :—

$$6CO_2+6H_2O+673{,}000 \text{ calories} = C_6H_{12}O_6+6O_2,$$

where 673,000 calories represent the amount of energy needed to promote the synthesis of one gram-molecule of glucose and is equal to the amount of energy evolved in the reverse process, viz., the combustion of glucose, which has been accurately measured calorimetrically. This energy, which is necessary for photo-synthesis, is assumed to come from light absorbed chiefly by the two chlorophyll pigments (*a* and *b*) present in the leaf, which possess characteristic absorption bands in the red and blue-violet regions.

The quantum efficiency of photo-synthesis as measured by Warburg and Negelein [58, 59] with the alga Chlorella as the plant material, is 0·25 at wavelengths 6600, 5780, and 5461 Å and about 0·2 at the wavelength 4360 Å. This means that four to five quanta of energy are required for the conversion of one molecule of carbon dioxide into a carbohydrate. Later workers [60, 61, 62] have found values for quantum efficiency which are even lower than the value obtained by Warburg and Negelein. Since the energy in $5\,Nh\nu$ at the wavelength 4360 Å is 326,135 calories, while the energy required for the conversion of one mole of carbon dioxide into a hexose, according to the thermochemical equation given above, is only 112,167 calories, it must be concluded that about two-thirds of the radiant energy absorbed by the green plant is wasted in so far as the process of photo-synthesis is concerned.

The production of one molecule of glucose, according to the equation for photo-synthesis, requires the interaction of twelve molecules, six each of carbon dioxide and water. Such a reaction cannot possibly take place in one step. It is, therefore, assumed that the first product in photo-synthesis is formaldehyde, which subsequently polymerizes to yield glucose or other carbohydrate. The first person to suggest the formation of formaldehyde as an intermediate product in photo-synthesis was Von Baeyer (1870). Although the explanation given by him for the formation of formaldehyde is no longer regarded as correct, yet the idea that formaldehyde may be formed as an intermediate product has proved very fruitful. It has provided the basis for further investigations concerning the mechanism of photo-synthesis in plants and stimulated efforts to reduce carbon dioxide in the laboratory with the help of radiant energy.

The first definite attempt to reduce carbon dioxide in aqueous solution in the absence of hydrogen was made by Usher and Priestley [63]. These authors claimed to have obtained formaldehyde by irradiating aqueous solutions of carbon dioxide in quartz tubes with the light from a quartz mercury lamp. Moore and Webster [64, 65] found appreciable quantities of formaldehyde, when aqueous solutions of carbon dioxide, containing uranyl salts or colloidal ferric hydroxide, were exposed to direct sunlight for some days. The same authors also found a positive test for reducing sugars, when a concentrated solution of formaldehyde was irradiated with the light of a quartz mercury lamp. Baly, Heilbron and Barker [66] found no evidence for the formation of formaldehyde when conductivity water saturated with carbon dioxide was irradiated in quartz tubes with the light from a quartz mercury lamp, but a positive test for formaldehyde was obtained when carbon dioxide was passed continuously through water during irradiation. This led them to the conclusion that a photo-stationary state was established between aqueous carbon dioxide on one side and formaldehyde and reducing sugar on the other. Under normal conditions the amount of formaldehyde and reducing sugar was very small but this amount could be increased by increasing the concentration of carbon dioxide.

It may be recalled that the amount of energy required for the conversion of aqueous carbon dioxide into glucose is 112,167 calories for one gram-molecule of carbon dioxide. This is equivalent to the energy contained in a light quantum of wavelength 2535 Å. Therefore, sunlight which contains at the surface of the earth rays of wavelength greater than 2900 Å cannot be expected to promote photo-synthesis in a single operation unless some other source of activation such as an adsorbing surface is also present. If ultraviolet rays of wavelengths shorter than 2535 Å are used, it is highly probable that these rays will bring about the immediate decomposition of any formaldehyde or glucose that may be formed at the beginning. In this connection it should be remembered that carbon dioxide in aqueous solution absorbs in the region of 2100 Å, while formaldehyde shows an absorption band, extending roughly from 3500 Å to 2500 Å.

The importance of the issue involved led many workers to repeat the experiments mentioned above. Spoehr [67] was unable to find any evidence of the formation of formaldehyde. Similarly, Bauer and Rebmann [68] and Bauer and Buchi [69] failed to obtain positive results. Porter and Ramsperger [70] repeated Baly's experiment, referred to above, taking every possible care to prevent contamination of the materials. The result was negative, no trace of formaldehyde or reducing sugar appearing even after 60 hours' exposure. Dhar and Sanyal [71] employing direct sunlight claimed to have obtained formaldehyde from aqueous solutions of carbon dioxide with and without the use of inorganic photo-catalysts such as colloidal ferric hydroxide, ferric chloride, uranyl salts, methylene blue and methyl orange. Burk [72], in America, using sunlight of varying intensity failed to corroborate these results. But Dhar and Gopal Rao [73] repeated the experiments and reaffirmed the original claims of Dhar and Sanyal. Qureshi and Mohamad [74] carried out experiments with aqueous solutions of carbon dioxide, employing direct sunlight, ultraviolet light and the light from a tungsten filament lamp, but failed to obtain any indication of the reduction of carbon dioxide to formaldehyde or sugars, when special precautions were taken with regard to the purity of the materials employed.

A fresh stimulus to the subject was provided by the publication of a paper by Baly and collaborators [75], in which the authors claimed to have synthesized carbohydrates by the reduction of carbonic acid adsorbed on the surface of coloured powders, using visible light. The powders used were pure carbonates of nickel and cobalt. Nickel carbonate prepared electrolytically and activated by exposure to white light for six hours proved particularly active [76]. In later experiments Baly [77] employed supported catalyists, in which nickel carbonate, cobalt carbonate, ferric oxide and chromic oxide were deposited on aluminated kieselguhr. It was claimed that with such supported catalysts 0·002 gram of organic matter could be synthesized per gram of powder in two hours. These interesting results encouraged Bell [78], Scheile [79] and Qureshi and Mohamad [80, 81] to repeat the experiments of Baly and collaborators, but none of these workers succeeded in obtaining any indication of photo-synthesis. Recently Baly has found that NiO containing ThO_2 in the molecular ratio of $1ThO_2$: 24NiO is capable of promoting photo-synthesis. When kiesselguhr, coated with a tri-molecular layer of these oxides, is irradiated in presence of water saturated with carbon dioxide by daylight or the light of a tungsten filament lamp, carbon dioxide is converted into a carbohydrate. These experiments are described in Baly's recently published book on photo-synthesis under the heading ' The Final Achievement' [82].

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SECTION OF GEOLOGY

President:—RAJ NATH, M.Sc., D.I.C., Ph.D. (LONDON)

Presidential Address

(*Delivered on Jan. 5, 1942*)

THE JURASSIC ROCKS OF CUTCH—THEIR BEARING ON SOME PROBLEMS OF INDIAN GEOLOGY.

CONTENTS.

I. INTRODUCTION.

I thank you very sincerely for the honour you have done me in electing me the President of your section this year. I propose to deal with the Jurassic Rocks of Cutch, a subject which relates to another Indian State not very far from here, and on which very valuable and interesting work has been done within recent years.

The importance of the Jurassic Rocks of Cutch centres in

(1) the fossils, which occur there in considerable abundance, and

(2) the plant beds, which enable us to fix the upper limit of the Gondwana System.

These points of interest were realized as early as 1868 as recorded by Thomas Oldham (1869, p. 31), the then Superintendent of Geological Survey of India and Director of Geological Museum, Calcutta. Even after nearly seventy-five years of geological investigations in India, they have not yielded this place of pride, especially with respect to the plant beds, to any other area discovered since then. Subsequent researches have only enhanced their value and have created one more point of interest, viz.

(3) the excellence of the area, which makes detailed stratigraphical work and mapping of the groups and zones possible.

II. The Jurassic Rocks of Cutch.

(i) *General Account.*

The Jurassic Rocks of Cutch occupy practically half of the State territories. They extend from the Patcham Islands to the middle of the main territory of Cutch and traverse the country in an east-west direction from one end to the other. They form three parallel anticlinal ranges of hills with an isolated mass to the east in Wagur. They have gentle dips (10° to 25°) to the south and high dips (20° to 50°) to the north. The tops have been denuded and the lower beds, largely belonging to the Chari Group, outcrop as domes along the anticlinal axes. It is possible that in the north under the Rann, i.e. between the first and the second anticline, the continuation of Wagur rocks are concealed. A big strike fault runs east and west along the northern foot of the hill range formed by the third anticline. There are a few minor faults mainly in the region towards Lakhpat. To the south the rocks are covered by the Deccan Trap. Igneous intrusives occur as sills interstratified with the beds and as dykes and ramifying intrusions.

The intrusion of the magma is connected with the igneous activity of the Deccan Trap period and may be of the same age. The folding of the Jurassic beds may also be more or less contemporaneous owing to the close relationship of the folds with the igneous intrusions. The dislocation of these beds is necessarily somewhat younger, since the faults displace these as well as the interbedded sills.

(ii) *History of Investigations.*

The history of the geological investigations of the province of Cutch may be said to date from Grant's paper (1837), read before the Geological Society of London, though papers, describing the great earthquake of Cutch of 1819 and its results, by Mac Murdo and by Burnes, and notice by Sykes (1834), respecting some fossils collected in Cutch by Captain Smee and Colonel Pottinger, had appeared earlier. Though Grant's paper deals with the geology of the whole province and is accompanied by a map, plates and list of fossils (plants were worked out by Morris and invertebrates by Sowerby), it, owing to its early date of publication when many old views which have since been discarded prevailed, has failed to add much to our knowledge of that area. The first satisfactory views of the geological structure of the area were made available by W. T. Blanford (1867, p. 17) as a result of rapid traverses of the country from south to north and back in 1863. But it was not till Wynne and Fedden's work (1869; 1872; T. Oldham, 1869) that a detailed account of the general geology of this area was available. They divided the Jurassic Rocks of Cutch into an upper and a lower series. Their 'upper series' comprised the plant bearing rocks (*Palaeozamia* beds) and their 'lower series' the marine fossil bearing rocks of the earlier workers. Wynne expressed that the 'lower series' were equivalent to Dogger (Middle Jurassic) and both the series together to Oolitic of England. But the results of the study of the Cephalopods by Waagen (1871; 1873, p. i) and of the stratigraphical relations of the rocks in the field by Stoliczka, during his short visit for that purpose in 1872, resulted in the establishment of four groups known as the Patcham, Chari, Katrol and Umia groups in ascending order.

The Patcham, Chari, Katrol and lower part of the Umia of these workers corresponds to the 'lower series' and the upper part of the Umia to the 'upper series' of Wynne. Waagen came to the conclusion that Patcham was equivalent to Bath Group, Lower and Middle Chari to Kelloway Group, Upper Chari and Lower Katrol to Oxford Group, Upper Katrol to Kimmeridge Group and Umia to Tithon Group. The beds at the Ukra hill, in the extreme west of Cutch, yielded some Cretaceous forms and were, therefore, assigned to that age. Subsequently R. D. Oldham in 1893 (p. 217) and Vredenburg in 1910 (p. 87) expressed their views regarding the relative ages of these groups. The main modifications introduced by Oldham on the basis of Stoliczka's field notes, over Waagen's view were, firstly, the enlarging of the term Umia to include the Cretaceous beds at Ukra hill also, and secondly, assigning the Upper Umia beds of Waagen, i.e. his Middle Umia, to doubtful Wealden age and thirdly, assigning the Cretaceous beds at Ukra hill to Upper Neocomian. Vredenburg agreeing with R. D. Oldham in the extended use of the term Umia introduced the following changes. Firstly, the Upper Chari was assigned to Oxfordian; secondly, the Lower Katrol to Sequanian; thirdly, Tithonian was omitted and the Lower Umia was assigned to Portlandian and Neocomian; fourthly, Upper Umia of Waagen, i.e. Middle Umia of Oldham to Barremian; fifthly, the Cretaceous beds were assigned to Aptian.

(iii) *Recent Researches.*

The recent researches on the Jurassics of Cutch began after a lapse of nearly half a century, as Waagen's work of 1873 was practically the last contribution on this subject.

Raj Nath with the object of establishing a detailed succession of the Jurassic Rocks of Cutch, to develop a local detailed faunal time-scale, and also to find out how far the field evidence in India would support the hemerae of Buckman, carried out detailed field investigations coupled with detailed mapping in the year 1927. More or less at the same time, Dr. Spath who had worked out Blake's collection of ammonites (Spath, 1924) was entrusted by the Geological Survey of India with the much-needed revision of the Jurassic Cephalopods of Cutch. In addition to this material the collections of Raj Nath, of Mr. J. H. Smith and that of others were also at his disposal. He also had free consultation of the geological map and of other field observations then freshly made by Raj Nath.

Patcham and Chari Groups.—Raj Nath with the object of zoning divided the Patcham and the Chari beds at one locality, Jumara, into 26 beds and mapped them as such on 4″ = 1 mile scale map (1934a, p. 346). From the same locality Blake had made his collection of ammonites and had numbered his beds from 1 to 14, but unfortunately after his death his field notes were lost. Since the beds below No. 21 of Raj Nath are mainly calcareous rocks and limestones, while bed No. 21 and those above it are mainly shales, Raj Nath on the basis of lithology fixes the division between Patcham and Chari at the base of his bed No. 21. Dr. Spath, however, on the basis of palaeontological grounds, fixes the limit much lower down at the base of bed No. 24. Since the two groups, Patcham and Chari, have distinct lithological characters (as pointed above), lithological considerations should weigh more in drawing a boundary between them than the palaeontological considerations. Further, *Macrocephalites triangularis*, which has been chosen by Dr. Spath as a zone fossil for Lower *Macrocephalus* beds, is not restricted up to bed No. 24 only, but it extends below to beds No. 25 and 26 also. The case, therefore, for lithological considerations is all the more strong.

According to all the earlier workers only Patcham was regarded equivalent to Bathonian. Raj Nath on the basis of an unconformity observed by him between beds No. 23 and 22 and on the find of a Callovian form, a new species of *Nautilus*, extended Callovian down into the topmost Patcham. But Dr. Spath extends Bathonian right up to bed No. 10, i.e. roughly up to the top of Middle Chari. He regards his Patcham Group, i.e. beds below No. 24, as equivalent to Lower Bathonian and his *Macrocephalus* beds, which are from bed No. 24 to 10, i.e. roughly Lower and Middle Chari, as equivalent to Upper Bathonian. He subdivides his *Macrocephalus* beds into lower, middle and upper divisions, comprising respectively of beds No. 24 to 22, 21 to 14 and No. 13 to 10 of Raj Nath and chooses three species, *triangularis*, *harveyi* and *tumidus* of Macrocephalitidae for the three respective divisions. Of these the first is a Cutch form and the other two are European species. The beds lying between his Upper *Macrocephalus* beds and Dhosa Oolite shales, i.e. from bed No. 9 to 1a of Raj Nath, have been grouped by Dr. Spath into *Rehmanni* beds, *Anceps* beds and *Athleta* beds, comprising respectively of beds No. 9 to 6, 5 and 4 and No. 3 and 2 of Raj

Nath. The three respective divisions are characterized by Reinekeids of early *rehmanni*-group, intermediate *anceps* group and of bituberculate *fraasi*-group of the *athleta* beds. He by extending the Bathonian restricts the range of Callovian to his *Rehmanni* beds and *Anceps* beds. He assigns his *Athleta* beds and Dhosa Oolite shales, i.e. beds No. 3 to parts of 1, to Divesian, and the Brown (Lower) and Green (Upper) Dhosa Oolites to Argovian. As a result of the study of the Brachiopod fauna (1934b, p. 351) Raj Nath has named bed No. 7 as *Zeilleria Zone* because *Zeilleria rostellata*, Kitchin is very abundant in, and exclusively characterizes, this bed.

As the Golden Oolite bed occurs only at two localities, viz. Jhura and Keera domes in the Lower Chari beds, Raj Nath thinks it cannot be said to mark any definite horizon in the stratigraphy of Cutch in general. According to Raj Nath there is a slight unconformity between the Dhosa Oolite 'proper', i.e. the Brown (Lower) Dhosa Oolite, and the Katrol beds, as the Green Oolitic bed, the Upper Dhosa Oolite, is not present everywhere. This is now supported by Dr. Spath on palaeontological grounds.

Katrol.—Waagen had divided the Katrol into two divisions, the Lower and the Upper, and he placed the Kantcote Sandstones in his lower division. Neither Raj Nath nor Mr. J. H. Smith (1912–1915) of Bhuj, who is an enthusiastic collector of fossils and has described some fine sections, visited Wagur, the eastern part of Cutch where Kantcote Sandstones are exposed, and therefore, no fresh field observations about them are available. However, Dr. Spath in 1924 included this formation in the Dhosa Oolite, but in 1928 he placed it with the Lower Kimmeridgian Belemnite Marls as a transitional group (of about *bimammatus* age) between the Dhosa Oolite and the Lower Katrol Ammonite bed. Now, on the basis of four species of *Ataxioceras*, which are unknown from Dhosa Oolite, but which are somewhat similar to the forms recorded from the *bimammatus* beds or their equivalents, such as the *Trigonia* beds of Weymouth, or the Harsova fauna of Rumania, he (Spath, 1933, p. 785) thinks that the whole of the Kantcote Sandstone is of Argovian (*transversarium* and *bimammatum*) age. He places it between Chari and Katrol proper as an independent group.

Raj Nath subdivided the Katrol proper in 1927, mostly on lithological grounds, into K_{I}, K_{II}, K_{III}, K_{IV} and renamed them in 1932 as Lower Katrol, Middle Katrol, Upper Katrol (e.g. at Gajansar) and Hard Sandstones. He had assigned the first two divisions to Kimmeridgian, the third to Portlandian and the fourth, being barren, could not be assigned to any age. Dr. Spath on the other hand has put Belemnite Marls of Jurun as the lowest bed of Katrol on palaeontological grounds like the presence in these beds of three species of *Aspidoceras*, forms such as occur in the Lower Kimmeridgian, but not in the Argovian. He thinks that a portion of lower part of Middle Kimmeridgian is not represented in Cutch and thus according to him there is a gap. He puts the Basal Katrol 'Ammonite Bed' second, the Middle Katrol Group (K_2) as third, Upper Katrol Group (pars = K_3) as fourth, Barren Upper Katrol Sandstones as fifth, Gudjinsar ('Katrol') beds as sixth, *Zamia*-shales of Nurrha and 'Katrol Beds' of Jara as seventh. Thus he has extended the limit of the Katrol to include beds up to the base of Umia Ammonite beds. Raj Nath, however, does not agree with him as regards the position of the *Zamia*-shales, which along with the 'upper series' of Wynne, as discussed in subsequent pages, are found to be Post-Aptian, not older than Middle Cretaceous, on structural evidence.

The fauna of the Basal Katrol beds is characterized by 'the increase in the number of species of Oppelids and Aspidoceratids' and by 'the comparative rarity of Perisphintids other than *Torquatisphinctes*, and the complete absence of *Idoceras* or *Ataxioceras*. This last especially might easily be taken to prove the absence, in Kachh, of at least part of the Lower Kimmeridgian' (Spath, 1933, p. 789). According to Dr. Spath the two genera, *Glochiceras* which is well represented and confined to these lowest Katrol beds and *Taramelliceras*, point to a Middle Kimmeridgian age. Further, the ammonites of the next higher Katrol beds too support Middle rather than Lower Kimmeridgian age for the Basal Katrol beds.

The most notable feature of the Middle Katrol Group is the abundance of *Pachysphinctes*. *Streblites* and *Waagenia* persist and *Aspidoceras* is still common, all these point to a Middle Kimmeridgian age, approximately corresponding to the European *steraspis* zone.

The Upper Katrol beds have yielded the following intermediate forms in addition to those which persist from Middle Katrol:—

Aulacosphinctoides maridionalis, Spath.
Virgatosphinctes (?) *indosphinctoides*, Spath.

The fossils collected at Gajansar from beds resting directly on the Dhosa Oolite are of special interest. From their lithological position they were correlated by the earlier observers with the Lower Katrol Ammonite bed of the south, where the Upper Dhosa Oolite or equivalents of the Kantcote Sandstone and the Belemnite Marls are missing. *Haploceras elimatum*, which is common in the Antsalova fauna of Madagascar, is also the commonest ammonite at Gajansar. On the negative evidence of the absence of early species according to the European standards, the Gudjinsar beds and those at Nurrha and at Jara are intermediate in age between the Upper Katrol beds of the South Cutch and the Tithonian Umia group of the north-west (Spath, 1933, p. 797).

• *'Umia' of Raj Nath, i.e. Lower Umia of Waagen.*—In the division of Umia Group Dr. Spath has followed Waagen, and has adopted two subdivisions, i.e. Umia Ammonite bed and Upper Umia Plant (and *Trigonia Crassa*) beds. But Raj Nath on the basis of field evidence has restricted the term 'Umia' to only the Lower Umia of Waagen and has divided it into five divisions: (1) Barren sandstones and shales, (2) the three Green Oolitic beds which have yielded the Tithonian ammonites, (3) Barren sandstones, (4) *Trigonia* beds, and (5) Barren rocks.

The three Green Oolitic beds of Raj Nath (i.e. the Basal Umia Ammonite bed of Dr. Spath) which are separated from the underlying Katrol beds by a great thickness of Barren sandstones and from where he collected all his Umia ammonites, have yielded *Micranthoceras* and all the numerous *Virgatosphinctes*, a form so dominant in the Umia beds. According to Dr. Spath (1933, p. 798) the Umia beds are of Lower Tithonian age, as in Madagascar *Micranthoceras* occurs with *Hildoglochiceras kobelli*, a Portlandian form, while in Mexico *M. microcanthum* is associated with *Proniceras* and *Durangites* which are almost certainly younger than *H. kobelli.* Moreover, he thinks that there is nothing in the Umia fauna that indicates the Upper Tithonian age.

The *Trigonia*-bearing beds overlie the three Green Oolitic beds and are separated by a thickness of 200–300 ft. of intervening sandstones. Kitchen has recorded the occurrence of the following forms of *Trigonia* from the Umia Group. These forms are grouped here into two sets: (1) those forms which are from such localities where, according to Raj Nath, the *Trigonia*-bearing beds overlie the Tithonian beds, and (2) those forms which are from such localities where the stratigraphical positions of the beds yielding Trigonias are not very definite as yet.

I. From localities where the Trigonia-bearing beds overlie the Tithonian beds.

Trigonia parva, Kitchin—S.E. of Ghuneri.
,, *crassa*, Kitchin (abundant)—N.E. of Ghuneri, Haroda, N.E. of Umia.
,, *cardiniiformis*, Kitchin—Ghuneri.
,, *retrorsa*, Kitchin—N.E. of Ghuneri, N.E. of Umia, Haroda.
,, *spissicostata*, Kitchin—N.E. of Umia.
,, *dubia*, Kitchin—N.E. of Ghuneri, Haroda.
,, *V-scripta*, Kitchin—N.E. of Ghuneri.
,, *recurva*, Kitchin—N.E. of Ghuneri, N.E. of Umia.
,, *mamillata*, Kitchin—N.E. of Ghuneri.
,, *ventricosa*, (F. Krauss)—N.E. and S.E. of Ghuneri, Haroda, N.E. of Umia.
,, *pulchra*, Kitchin—S.E. of Ghuneri.

II. From localities where stratigraphical positions of the beds yielding Trigonias are not very definite as yet.

Trigonia tenuis, Kitchin—Kukrooa, Adooi, E. of Chobaree Wamka, N.E. of Jara.
,, *smeei*, J. de C. Sowerby—Kukrooa, E. of Chobaree Shahpur, W. of Trummo.
,, *trapeziformis*, Kitchin—S.E. of Trummo.
,, *remota*, Kitchin—S.E. of Habbye, Kass Scarp.

The age of the Trigonias of the first set would, therefore, be at least Upper Tithonian, if we accept according to Dr. Spath the Lower Tithonian age for the underlying Umia Ammonite beds, i.e. the three Green Oolitic beds. But if we take into account the time interval represented by the Barren Sandstones, occurring in between the two fossiliferous horizons, the age of the *Trigonia* beds would be at least Lower Cretaceous. This conclusion finds support from the observations of Kitchin (1903, p. 3) who on the basis of the study of the Trigonias from Cutch stated: 'Though none are identical with European forms, one, *Trigonia ventricosa*, Krauss, which is common also in the Uitenhage beds, is a representative of an essentially Cretaceous section of the *Trigoniae*; moreover, it bears a very strong resemblance to the Cretaceous *T. tuberculifera*, described by Stoliczka from Southern India. There are other *Trigoniae* occurring with *T. ventricosa* which likewise bear a Cretaceous aspect; one of these is referable to the same section of the genus as *T. ventricosa*, while the other may be classed with the Pseudoquadratae, a small group exhibiting characters which are usually associated with a Cretaceous facies......'.

'It seems most probable that in the Oomia Mollusca we are dealing with a passage fauna which, while retaining a partially jurassic aspect, was characterized also by the presence of types which marked the incoming of a true cretaceous facies. It is not improbable that such an intermingled fauna may have lived in this region at a time when wealden strata were being deposited in Europe. Such an opinion as this was expressed by Staticzka on his return from work among the rocks of the Cutch Series.'

The *Trigonia*-bearing beds are overlain by a considerable thickness, at least 1,000 ft., of Barren Rocks.

Ukra Beds and Bhuj Series.—Raj Nath (1932), on the basis of structural evidence, places the upper division of Umia of Waagen including *Zamia*-beds, i.e. the 'Upper Jurassic Series' of Wynne, over Aptian beds of Ukra hill and has named them as Bhuj Series. Thus according to him there is an unconformity between the Katrol and Bhuj Series, the latter apparently lying directly over the former in the field. He believes that an interval of non-deposition or even of erosion occurred before the rocks of the Bhuj Stage were deposited on the Katrol beds. The presence of this unconformity revealed by Raj Nath finds further support from the following observations of Dr. Spath (1933, p. 737): '........Mr. Smith has now found a Katrol ammonite (*Aulacosphinctoides* sp., p. 529) in the bank of a lake two miles north of Bhuj; and since the embankment was made up of material dug from the bed of the tank (Chhota Rudra Mata tank) only a few feet deep, it shows that the Middle Katrol beds here come almost to the surface. Again two miles north of Ler, on the surface of cultivated fields, weathered Lower Katrol Perisphinctids have been picked up......'. To my mind the occurrence at Nurrha, in the Katrol stage, of plant fossils having a very strong floral relationship with the Bhuj plant fossils, is due to this unconformity.

As according to Raj Nath the Bhuj Series are Post-Aptian, he is of opinion that they are not older than Middle Cretaceous, they may be slightly younger.

III. Upper Limit of the Gondwana System.

The significance of the plant-bearing beds, i.e. the Bhuj Series of Raj Nath (= the 'Upper Jurassic' Series of Wynne), for fixing the upper limit of the Gondwana System because of their association with the marine fossiliferous beds, was realized as early as 1868 (T. Oldham, 1869, p. 31). Their importance from this point of view has remained unchanged during all these years, but their stratigraphical position has remained unsettled up till now.

In the earlier stages of investigations, even the mode of association of the plant-bearing beds (regarded as *terrestrial*) with the marine (Jurassic) fossiliferous beds was uncertain. Captain Grant left it doubtful; while W. T. Blanford (1867, p. 17) believed that the plant-bearing rocks were actually intercalated with the marine Jurassic rocks. Wynne arrived at the conclusion 'that a very few and very imperfect remains of plants do occur in layers distinctly intercalated with the truly marine beds, and have probably been drifted into these localities from shores adjoining the seas in which the mollusca, now found fossilized in these beds, then existed. But as a whole the beds in which the well-marked *Palæozamiae*' (now called *Ptilophyllum*) 'occur are decidedly younger than those containing the truly Jurassic *Ammonites* and other characteristic fossils; and that they constitute an upper zone, but belonging to the Jurassic period' (T. Oldham, 1869, p. 31).

The question of the age of the plant-beds has been still more controversial than their mode of association. The conclusions arrived at, range from Bathonian to Middle Cretaceous. The evidences on which the age of the plant-bearing beds has been based, fall into two categories:—

(i) direct evidence based on the plant fossils contained in them, and
(ii) indirect evidence based on the invertebrate fossils contained in the beds stratigraphically older or younger than the plant-beds.

In the earlier years the plant-beds of Cutch were regarded as equivalent to Rajmahal (Wynne, 1869, p. 51) on the basis of few forms of *Ptilophyllum* (like *Ptilophyllum cutchense, P. acutifolium*) found common at the two places. But Feistmantel (1876a, p. 34) as a result of the study of the several fossil floras of India, including those from Cutch, did not agree in identifying the horizon of the Cutch with that of the Rajmahal. He assigned the Cutch horizon to Middle Jurassic (Bathonian) and Rajmahal to Lower Jurassic.

The evidences of the second category, though indirect, are regarded to be more reliable because of the marine invertebrate fossils contained in the beds associated with the plant-beds. On the basis of the Ammonites contained in the Umia Ammonite beds, taking them as immediately older than the plant-beds, they are referred to uncertain Post-Tithonian age by Waagen (1873, p. i), and to Upper Tithonian age by Dr. Spath (1933, p. 865). On the strength of results obtained by Kitchin (1903, p. 3, 1913) from the study of *Trigonia* and on the similarity of the marine Umia beds to the Uitenhage Series of South Africa, they are referred to Lower Cretaceous by Cotter (1917, p. 23). This view is still accepted in recent publications (Fox, 1931; Fox and others, 1940, pp. 71–77).

After the discovery of beds of Aptian age in Cutch by Stoliczka, the plant-beds were then regarded to be occurring between the limits of two marine beds, one of Tithonian age and the other of Aptian age. They were consequently referred to Wealden by Stoliczka, Wealden or even Neocomian by W. T. Blanford (1878, p. 119), doubtful Wealden by R. D. Oldham (1893, p. 217), and as Barremian by Vredenburg (1910, p. 87).

The Bathonian or even lower age as favoured by the plant fossils was at great variance with the age, anything between Upper Tithonian to Lower Cretaceous, indicated by the invertebrate fossils. This discrepancy between the two evidences —from the plant and from the animal remains—which Feistmantel aptly calls 'palaeontological contradiction', led to a long controversy between him (1876a; 1876b) and W. T. Blanford (1876; 1878).

Coming to recent researches, Raj Nath (1932, p. 173), as mentioned in the foregoing pages, has assigned the plant-beds to Post-Aptian age. In other words, the Umia Stage of the Gondwana System is Post-Aptian, probably of Middle Cretaceous age.

The discovery of a silicified palm wood which was collected from the plant-beds by the party from Benares and which has been described and named as *Palmoxylon mathuri* by Prof. Sahni (1932, p. 322), now solves this 'palaeontological contradiction' by providing an evidence of their higher age on the basis of plant fossils themselves, as the range of *Palmae* is from Upper Jurassic to Recent.

The flora of the plant-beds already contained elements differing widely in age, and the new find is an addition to the list. This feature may be to some extent characteristic of the flora itself, but in my opinion, it is to a large extent due to want of recognition of horizons in the plant-beds.

The Bhuj Series is of great thickness, but a considerable portion of this series over a large area has been eroded away, so much so, that at some places inliers of the underlying Katrol beds occur in the areas occupied by Bhuj Series (viz. at Chhota Rudra Mata tank only two miles north of Bhuj). The series is more or less horizontal and therefore the elevations of the localities ought to have been taken into consideration in the study of the plant fossils from this series. In the light of these observations, I believe that the Bhuj Series consists of at least three horizons, viz. *Zamia*-beds at the bottom, *Ptilophyllum*-beds at the middle and *Palmoxylon*-beds at the top. As expected, the uppermost beds of the Bhuj Series—the *Palmoxylon*-beds—occur as remnant patches, only on the top of the isolated hills of igneous intrusives, standing in the midst of the plain occupied by the lower horizons of the Bhuj Series.

IV. Concluding Remarks.

I have attempted to place before you an account of recent researches on the Jurassics of Cutch, with their bearing on the Upper age limit of the Gondwana System. Detailed zoning has revealed that in the Jurassic strata of Cutch there are at least six unconformities: (1) between beds No. 23 and 22 at Jumara; (2) between the Brown, i.e. the Lower Dhosa Oolite and the Katrol beds; (3) of the age of Belemnite Marls of Jurun; (4) of the age of lower part of Middle Kimmeridgian; (5) between the Dhosa Oolite and the Gudjinsir 'Katrol' beds at Gajansar; (6) between the Katrol and Bhuj Series. This shows that the sea, which had invaded Cutch, North-East Kathiawar, and Rajputana during the Upper Jurassic times,—and also during a part of Middle Jurassic times, if we accept the standard of the Jurassic System recommended by Siemon Wm. Muller (1941, pp. 1421–1443)—oscillated very much. The presence of such forms in Cutch as are comparable to forms of Himalayitidae of the Spiti Shales, indicates that to the north this sea was connected to the Tethys Sea, occupying the present position of the Himalayas. There also existed some form of connection between the Cutch sea and the sea in the south as revealed by the close faunal relationship between the Jurassics of Cutch and Madagascar. I do not wish to detain you longer with other problems of palaeontological and stratigraphical interest connected with these formations and their equivalents in other parts of India and adjacent countries.

The Jurassic Rocks of Cutch as already pointed out are very rich in fossils. In fact the earth is a great cemetery of these lowly creatures who serve so wonderfully even after their death by helping the geologist in the construction of the paleogeography of the past and in building up stratigraphy, which is helpful in the exploration of the minerals of economic importance. What service is the man capable of? The present civilized man, at any rate, has exhibited it in this war which is a ruthless butchery and destruction of life and colossal waste of resources of the world. The blame for this destruction is often placed at the door of science. The scientists discover things in the spirit of devotion for truth and selfless service. There are enough resources in this world to make the entire mankind happy if only things are done in a scientific manner.

The subject of geology is of great cultural interest and of great economic importance (Watts; Parks; Holland), but it is really unfortunate that it has not received as much stimulus in India as in other countries. In one of the recent sessions, the British Association for the Advancement of Science constituted a committee which has recommended geology as a suitable subject for study at school stage (*Annual Report* for 1935, 1937 and *Nature*). It is high time that such universities in India as are teaching geology from the B.Sc. stage should include geology as a subject for studies at least at the Intermediate stage and other universities should also include geology in their undergraduate and graduate courses in science. To make the full use of the knowledge of geology for the industrial development of India, I strongly suggest that the following steps, in addition to others, should be taken at an early date:—

No. 1. The staff of the Geological Survey, which is too meagre for a vast country like India, should at least be doubled.

No. 2. A Mineral Research Institute should be established to investigate the problem of utilization of minerals already known in India and other allied problems.

No. 3. A well-equipped department for the mineral investigations with the help of geo-physical methods should be placed at the disposal of the above Institute.

The prosperity of a country depends largely upon its mineral wealth, and I need not emphasize the importance and the need for systematic researches to be carried out for the proper utilization and conservation of India's mineral wealth. Let us hope for the early advent of the period when the importance of geology to Mankind will be properly realized in this country.

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SECTION OF GEOGRAPHY AND GEODESY

President:—GEORGE KURIYAN, B.A., B.SC. (LOND.)

Presidential Address

(Delivered on Jan. 5, 1942)

SOME ASPECTS OF THE REGIONAL GEOGRAPHY OF KERALA

LADIES AND GENTLEMEN,

I must at the outset express my most profound thanks to the members of the Geography section for having conferred upon me this very great honour of presiding over its deliberations. Knowing as I do my serious limitations, I feel that the choice has been particularly unfortunate, but with your co-operation and forbearance, I shall endeavour to discharge the onerous duties that have devolved upon me, to the best of my ability.

This section was separated from Geology and created as an independent one as late as 1938 for the Jubilee Session of the Congress and the sword of Damocles is now hanging over it. We have been informed that this is the last year when the section will have an independent existence and it passes one's comprehension why even in these days of war, geography should be the Cinderella of Universities and learned societies. It is very doubtful if a sufficiently strong case has been made out by the authorities of the Association to foreclose so immediately and at so short a notice, the deed of hypothecation that had been granted to this subject. I do hope and pray that under the able guidance of the General President, Prof. Wadia, some chance will be given to enable the geographers in India to have an independent existence in the Association.

Except for Dr. A. M. Heron, the first President of this section, every other honourable predecessor of mine had, as the theme of his presidential address, a subject with an all-India outlook, but I have deliberately changed this established precedent and am proposing to give in this short address 'Some aspects of the regional geography of Kerala'—a very small part of India—almost an infinitesimally small part. Regional studies in India are yet in the infant stage and we have very few detailed accounts of the several parts of India.[1] It is for

[1] Note the exceptions, Chatterjee's Plateau of Maghalea, Pithawalla's Sind, Pant's Kumaon Himalayas, Mukherjee's Bengal, etc.

the Geographers in the several Universities in India to compile detailed regional studies in imitation of those admirable ones, so ably produced by the French school of Geographers and with this end in view, I have deliberately chosen one of these regional studies to form the main theme of my presidential address this afternoon. Although it is not possible for me in the short space at my disposal to give an elaborate account of the unit that I have chosen, nevertheless, I hope and feel that the results of my enquiry are likely to be both interesting and fruitful.

INTRODUCTION.

From very early times, the southern parts of the country lying to the west of the Western Ghats have been designated Kerala. Traditionally it extends from Gokarnam (near Goa) to Cape Comorin and is said to have been regained from the sea by Parasu Raman. Standing somewhere near Gokarnam Parasu Raman is supposed to have thrown an axe[1] with tremendous force right over the sea. By some wonderful miracle it is supposed to have been carried onwards as far as Cape Comorin and all the sea between the two places dried up and was transformed into that tract of level land to which we now give the name of Kerala. I have elsewhere[2] shown that such legends are not to be merely rejected as altogether puerile, that they chronicle in the imaginative style of the poets the effects of the changes of the shoreline, merely describing in a figurative manner that the lowlands of Kerala have been raised from the sea.[3]

Innumerable suggestions have been put forward regarding the origin of the word 'Kerala' and when authorities of great repute have differed so remarkably, it is difficult to arrive at any definite conclusion. Probably as the Rev. Mr. Foulkes contends, Chera and Kerala denote the same country, Kerala being the Canarese dialectical form of the word Chera. Dr. Rottler in his Tamil dictionary and Dr. Gundhert in his Malayalam dictionary subscribe to this view.[4]

[1] In another form of the legend a rice winnow.

[2] Indian Geographical Journal, Vol. 16, No. 4.

[3] Trans. Orient. Hist. MSS., Vol. 1, page 153 and Vol. 2, page 65. According to orthodox Christian chronology, the nearest conjecture we can form regarding the date of Parasu Raman is that he lived sometime during the 1000th year after the flood.

[4] The word is supposed to have been derived from the word Keram—a contraction of Nalikeram, the Sanskrit name for coconut. The Periplus Maris Erythroei (McCrindle) gives an exhaustive list of the imports and exports of the several trade centres in Malabar and it is noteworthy that there is no mention among these of coconuts or of coconut produce of any description. If the coconut tree had existed at this time in this region, it is certain that the produce of such a notable fruit

The extent of Kerala varied very considerably in several periods of history. Pliny in the first century A.D. makes a mention of the country without giving its exact frontiers. The Periplus is more definite and states that 'it extends from Nouro (Cannanore) and Tyndis (Tundi) in the north to Nelcynda (Nirkunnam or Niranam ?) and Barake (Bakare, Barakare ?, i.e. Porkad ? or Mavelikara ?) in the south'.

Some of the more remarkable of the vegetable and animal products of the Malabar coast have been known to western nations from times antecedent to the Christian era and have been the objects of maritime enterprise and commerce, through all the succeeding centuries. Perhaps as early as the time of Moses, the great Jewish law-giver, this commerce existed, for cinnamon and cassia played a part in the temple services of the Jews; and at any rate, the commerce existed in the time of King Solomon (B.C. 1000), for the Bible narrative records that 'silver' was nothing accounted of in the days of Solomon, that everything was of 'gold'. 'The king had at sea a navy of Tharshish . . . . . bringing gold and silver, ivory, and apes, and peacocks'. With the exception of perhaps silver, these are all products of the Malabar coast and the Biblical name for the peacock—tuki—is evidently the Tamil-Malayalam tokei, the bird of the tail. Again Solomon obtained his gold from Ophir. It may, however, be pointed out that Beypore lies at the mouth of a river of the same name which till recently brought down gold from the auriferous quartz regions of S.E. Wynaad, the

tree would have been exported and would then have been mentioned. It may thus be safely concluded that coconut—the southern tree as the Malayalees call it—was introduced after the first century A.D. It was probably cultivated on the coast at the time of the Syrian Christian Copper plate grant (early part of the ninth century A.D.), for the professional planters of the coast, the Tiyar or the Cingalese, organized as a civic guild, were then well established and tradition says that they came from the south, bringing with them the southern tree, the coconut to wit. Vide Logan, *Malabar*, page 80. (Tiyan is a corruption of the Sanskrit word Dvipan passing through Tivan, a name which is even now applied to the caste. Simhala was the ancient name for Ceylon and the other caste name of the planters must have passed through Simhalan to Sihalan and Ihlavan and finally to Ilavan.)

Another theory as suggested in the Keralolpathi is that the country takes its name from Cheraman Keralan—one of the sovereigns among the Perumals. This is however equally impossible as there is every indication to show that the country had its name long before the advent of this legendary Perumal. Vide Nagam Aiya, *Travancore State Manual*, Vol. 1, page 2.

Again in the Puranas it is said that Parasu Raman desired the Trimurthis and the Devas to give a fitting name to this land and Lord Siva called it Kerala in honour of the marriage of the Sea King's daughter to Keralan, son of Jayanti.

It is thus clear that the origin of the word cannot be satisfactorily explained.

[1] I Kings X, 22.

mines of which were well worked in prehistoric times;[1] that Tyndis, 'the village of great note situate near the sea' mentioned in the Periplus, lies close to Beypore on the southern bank of the same river and the country lying inland from these places is still called Ernad—the bullock—that is grazing country. If Ophir as is generally supposed meant the country of Abhira or cowherds (Kurumbar and Kurumbranad?) then the name Ophir fits the locality exceedingly well. The fact remains that even to this day Jewish colonies are settled on the coast and if their progenitors, often of course replenished by further immigrations, did come with King Solomon's fleets, they have at least traditions which carry back their arrival on the coast to the time of their escape from servitude under Cyrus in the sixth century B.C.[2]

This region of Kerala has a certain peculiarity of its own; it lies on the south-western corner of India, cut off from the east coast and the Deccan by the barrier of the Western Ghats, which is broken only in two places within the limits of the area, in the Palghat Gap (utilized by the S.I.Ry.) and in the Aramboly gap in the south (utilized by the Nagercoil-Tinnevelly road). At Tenkasi the S.I.Ry. tunnels through the Ghats. Climatically the whole of the west coast including the Konkan region which lies further north, is clearly different from the adjoining regions. The rainfall in Kerala is ordinarily very heavy and the crops need irrigation but rarely. The Konkan region has apparently much in common both geologically and climatically with the region of Kerala, but the language is Kannada, the customs, manners, mode of dress, the devolution of property, etc., are all different. It has therefore been considered advantageous to limit the scope of this paper to the cultural region of Kerala where Malayalam is the predominant language. I have thus included in this region, the Indian states of Travancore and Cochin and the District of Malabar together with the taluk of Kasaragod which lies in South Kanara—the predominantly Malayalam speaking region.[3] It extends from 8° 4′ N. to 12° 48′ N. and 74° 53′ E. to 77° 35′ E. It is bounded on the north by the Mangalore taluk of the District of South Kanara, on the east by Mysore, Coorg, the Nilgiris, Madura, Ramnad and Tinnevelly and on the south and west by the Arabian Sea. The eastern boundary in general coincides with the watershed of the Western Ghats and this is particularly true of the eastern frontier of Travancore. The distance between the Ghats and the sea varies considerably. It is maximal in the northern parts of Travancore where it is in excess of 60 miles while in

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[1] In the opinion of the G.S.I. it would be commercially feasible to extract gold from this region even today.

[2] Logan, *Malabar*, Vol. 1, page 248.

[3] North of Chandragiri river, Kannada becomes important.

north Malabar it diminishes to less than 20 miles and in the south almost tapers to a point at the Cape. The region is well watered by numerous westward flowing perennial torrents all of which have their origin in the Western Ghats. The longest of them is Ponnani (Bharata Puzha) which is only 156 miles in length. Clearly the rivers of Kerala bear no comparison with the much longer rivers like the Cauveri, Kistna or Godavary of the Deccan. Most of the rivers just before they enter the sea are deflected southwards and flow in a generally southerly or southwesterly direction parallel to the coast.[1]

The backwaters and canals are a peculiar feature of the area extending from Tirur in the north to Trivandrum in the south for a distance of about 220 miles. Although they lie detached from one another, canals have been constructed to link them up, thus affording cheap and easy continuous communication. In days gone by, when wheeled and pack bullock traffic was the only means of transport known, this system of waterways must have been the cheapest and the best means of communication. It is therefore easily comprehensible how the backwater system exercised considerable influence on the political, commercial and industrial activities of the country. All the foreign nations who started their commercial enterprises in the West Coast were eager to get hold of sites for factories and fortresses at advantageous positions on the rivers and backwaters.[2] The Europeans were not the only peoples who saw the advantages of settlements on a river bank, or at the mouth of a 'Kayal'. Mention must be made that more than 90% of the Mahomedan settlements even today are situated likewise.[3]

Geology.

The main rock formations of the region are the prevalent and foundational crystalline gneisses, the lateritic formations, the Warkkalay beds and the recent deposits.

Crystalline rocks of the region consist of various kinds of gneisses of which charnackites and leptynites are the most common; north is charnackite and south is leptynite. The

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[1] Note the contrary feature on the east coast. Possibly this is due to the N.-S. direction of the currents in the Arabian Sea along the coast of Kerala. It may also be due to this that the lakes and backwaters get wider towards the south while they are narrower in the north. The deposit of river borne material is much greater in the north than in the south.

[2] e.g. The Portuguese and Dutch establishments at Cannanore with an outpost at Mt. D'Eli commanding the river navigation of North Malabar, the English factory at Tellicherry, the French at Mahe, the Danish at Edava, the Dutch at Tangassery, etc. The Dutch, Portuguese and English fought for Chettwa, because it stood at the mouth of a broad river with an extensive backwater system in the north.

[3] The Mahomedans are mainly commercial in their occupation.

leptynites overlie the charnackites in general. Although the prevailing rocks are leptynites in the south, the charnackites are seen to underlie the leptynites in valleys and other depressions, while no leptynites are seen in the north even in deep valleys. In a remote geological age, probably the leptynites extended further north and covered the whole area now overlain by charnackites and other nongranetiferous rocks. It is conceivable that the Western Ghats were formed by a thrust of charnackite magma below a previously formed leptynite crust, which was denuded away in the course of ages.[1]

Laterites.—The gneisses of Kerala have an extraordinary tendency to weather into white, yellow or reddish felspathic clayey rocks which often very extensively and ultimately become laterites in many places, but the change from weathered gneiss to this belt is not sharp. There is no doubt that the upper surface generally over large areas is lateritized to a certain depth irrespective of the constitution of the strata. The alteration of the gneisses is irregular and begins at an elevation of about 400′ above sea level and it extends as a fringe of varying width along the lower slopes of the mountain. At a still lower level between 200 to 250′ there is a better defined belt of more decidedly lateritized form of weathered gneiss, in which the unaltered rock occurs less frequently, and then always in more or less flatly rounded humps and masses, which never rise above a general dead level.[2] In Malabar the plateau character of the lateritic gneiss is very well developed. It is therefore true to assume as a general rule that lateritization is characteristically found at an approximate elevation ranging from 250′ to over 600′. I have elsewhere [3] made a detailed study of the topography of the lateritic regions of Kerala, wherein it has been shown that the narrow West Coast presents unmistakable traces of a plateau or terraced character which is best displayed about Trivandrum, Malappuram and in several parts of the Chirakkal taluk.

Warkkalay formations.—In some parts of Kerala, to the west of the lateritic formations are found the Warkkalay beds [4] which constitute the sea-ward edge of the plateau and they present similar features, bare, grass grown, long flat undulations of laterite, forming the higher ground, about 250′ above the sea level. They extend as far north as Kottayam bordering the backwater tract in the east and probably much further northward as is evidenced by the lignite deposits in Cannanore

[1] The absence of the leptynite in the regions of heavier rainfall suggests this hypothesis.

[2] Records of the Geology of Travancore, Vol. 1.

[3] Proceedings of the Indian Science Congress, Jan. 1941, and Indian Geographical Journal, Vol. 16.

[4] The most characteristic formation of the Warkkalay beds is the lignite bed which is exposed at the base of the cliff at Warkkalay.

and Beypore. Somewhat similar beds occur further north near Ratnagiri on the Bombay Coast. The Warkkalay beds are, without doubt, aqueous in origin.

The marine lateritic terrace and the Warkkalay formations are probably of upper tertiary age and equivalent to the Cuddalore sandstones of the Coromandel coast, late tertiary or post-pliocene. They mark, like the long stretches of laterite and sandstones on the East coast, the last great or decided elevation of South India, prior to which, as is very probable, the Indian land arose almost directly from the sea by its Western Ghats.[1]

Recent Deposits.—West of both the lateritic formations and the Warkkalay beds along the coast, occur the recent deposits which are the usual blown sands and alluvial sediments of the low flat country, of perfect stretches of lowland almost at sea level, marked by sandy and alluvial flats. These widen out north from Quilon until at Alleppey there is a width in excess of 12 miles with the very extensive backwater which stretches far past Cochin. This is continued further north through the Trichur lake, the Taliparamba and Valarapattanam rivers to those on the Kadalundi river. To the south of Quilon and north of Calicut, this formation occurs as a very narrow strip bordering the sea.

Immediately after the upheaval of the Warkkalay formation, this backwater tract north of Quilon must have been an extensive bay[2] breaking its waves on the dry land which now forms its eastern boundary. Into this bay were discharged the waters of the Periyar, Pampa, Chalakudi, Ponnani, etc., heavily charged with sediments resulting in the formation of a sand bank which is represented by the present sea coast, north of Quilon. The lagoon formed between the sand bank and the main land was gradually silted up to give rise to the wet paddy lands and coconut groves which now characterize this tract. The comparatively deep kayals are only the remnants of the lagoons which have not been silted up. The marine nature of the formation is evidenced by the lowlying sands of the sea coast which consist of sea sands and calcareous matter, combined with various kinds of earth and clay.

Based upon the type of the main rock formations like the laterites, the Warkkalay beds and the recent sediments, it is possible to suggest that the region of Kerala has been lifted up from the sea in post-pliocene times. The remains of marine animals and plants found within the region almost conclusively confirm this suggestion. In addition, an analysis of the several

[1] Logan, *Malabar*, Vol. 1, page 26.

[2] The presence of coral reefs at Vazhappally in Changanacherry is certainly conclusive evidence of the much wider extent of the sea in those times.

place-names on the eastern shores of the backwater shows that the sea coast must originally have run along this area extending up to the foot of the Ghats.[1] The land of Kerala has been literally raised from the sea. The tradition of Parasu Raman having achieved this by superhuman powers is only the description of an apparently miraculous event in grand poetic style, with a considerable amount of embellishment.

It is thus seen that some general relations exist between the contours and the geological formations. The coastal lowland composed of recent sediments has a maximum elevation of about 250′ and east of it is the area of foot-hills ranging in elevation from 250′ to approximately 1,000′, where lateritization has taken place. Tongues of lowland, however, enter into this area through the course of the main river valleys. The metamorphic rocks of the highland region are generally found in areas with an elevation in excess of 1,000′.

Physiographically, it is therefore possible to divide Kerala into three natural units: (i) the coastal lowlands composed of recent sediments, where the general elevation is less than 250′; (ii) the foot-hill zone composed essentially of laterites, Warkkalay formations, etc., the elevation of which ranges from 250′ to 1,000′; and (iii) the highlands of metamorphic rocks where lateritization has not taken place and where the elevation is always in excess of 1,000′.[2]

CLIMATE.

The whole region has a very long coast and in close proximity to the sea are the high Western Ghats which in places reach even 8,000′. These high mountains protect Kerala from the dry hot winds of the Deccan and give it an excessive rainfall during the monsoon months.

The most important factor is the uniformity of temperature. On the sea coast the mean annual temperature is 81°F.; it rarely rises above 90°F. and it seldom falls below 70°F.; i.e., it is always hot, sometimes hotter but never very hot. The mean maximum for the year is about 86°F. and the mean minimum about 75°F. Kerala is free from extremes of temperature. On the West coast of India, the annual variation of temperature is small in the extreme south and increases rather rapidly northwards. It is twice as great at Bombay as in Calicut and over four times as great at Karachi. The diurnal range is about 10°F. in Kerala, where we have an almost unvarying warmth, in conjunction

[1] Indian Geographical Journal, Vol. 16.

[2] See Dudley Stamp, *Asia, a Regional and Economic Geography*, pp. 314–316, where a similar tripartite division is suggested. It is unfortunate that Dr. Stamp does not delimit the boundaries of these regions definitely.

with a uniformly moist atmosphere that is especially characteristic of the shores of a tropical sea.

Perhaps the most important cause for the maintenance of this very high temperature throughout the year, is the influence of the aqueous vapour in the atmosphere. One branch of the ocean current which sweeps the African and Madagascar shores impinges on the West Coast of India somewhere near Goa. This brings with it an atmosphere more or less saturated. And the ocean itself is at hand and the sea breeze, always saturated with moisture, flows steadily for several hours every day in the dry weather. Finally during June, July and August (the season of the south-west monsoon) the wind blows steadily both by day and night from the ocean and rolls up before it dense masses of vapour. The atmosphere is therefore throughout the year more or less in a saturated condition and the heat radiated from the earth is very largely absorbed by the aqueous vapour held in suspension in the air, which thus acts as a blanket, preventing the heat from being radiated out by night. A cloudless night, in this region, generally does not denote a cool night as in most parts of the world. There are compensating advantages for (i) the ocean never becomes superheated and the ocean winds are therefore comparatively cool, and (ii) as the dense masses of monsoon clouds shelter the region from the direct rays of the sun, the south-west monsoon is a season when the temperature of the atmosphere is low, in spite of the fact that the sun then attains its maximum altitude. The uniformity of temperature during this season is chiefly maintained by the latent heat of vaporization liberated by the condensing vapour.

Pressure.—A study of the barometric pressure [1] shows that the highest pressure occurs in January and the lowest in June. In January the pressure progressively increases from south to north and the difference in pressure between Trivandrum in the south and Mangalore in the north, steadily decreases through the months of February, March and April. In May, the pressure is the same throughout the region and in June when the lowest pressure is recorded, the south (Trivandrum) registers a higher pressure than the north (Mangalore). This reversal in pressure distribution continues for two months. After the monsoons, the pressure in the north rapidly increases while that in the south does so, less rapidly, till the highest pressures are recorded in January. This probably accounts for the higher rainfall during the south-west monsoon in the northern parts of Kerala (e.g., Calicut, Cannanore, Tellicherry and Mangalore lying still further north) and the predominance of the north-east monsoon to a

[1] The study is confined to the four stations of Mangalore, Calicut, Cochin and Trivandrum, as no inland records are available.

much greater extent in the months of October and November in the south (e.g., Trivandrum).

Place.	Rainfall during		Total Annual Rainfall.	Remarks.
Trivandrum	June, July and August	24·85	64·40	Notice the evenness of the distribution and the much smaller total in the year.
	September, October and November.	21·32		
	December to May	18·23		
Calicut ..	June, July and August	90·12	118·85	Notice the concentration in the season of the south-west monsoon and the poverty during the north-east monsoon.
	September, October and November.	23·95		
	December to May	4·78		

The northern parts of Kerala have a much higher aggregate annual fall but the distribution is extremely seasonal, while in the south, although the total rainfall is only half of what it is in the north, yet it is much more evenly distributed throughout the year. This contrast in distribution is fundamental.

Another important factor associated with the climate is the extreme regularity of the seasons. Towards the end of March and the beginning of April, the first distant mutterings of thunder are heard among the hills. In some years, these thunderstorms extend as far as the coastal regions regularly every afternoon; in others, the advent of these is not such a regular daily occurrence, nor is the hour at which they begin so marked. At first, the land wind gets the advantage and blows throughout the night; in the forenoon there is a lull, then as the inland surface of the country gets heated, the sea breeze rushes in. This continues until the thunderstorm commences, or the night sets in. As the season progresses, the western winds from the ocean usually gain in force, while the land winds from the east and north-east tend to fail. Towards the end of May, or the beginning of June, the south-west monsoon ultimately obtains mastery and regular rains begin and are finally ushered in by heavy banks of cloud to seaward, by a heavy swell from the west and by an electric storm of more than usual violence. In most years the south-west monsoon bursts on the Malabar coast during the first five days of June.[1]

[1] Sundar Lal Hora, *Field Sciences of India*, page 4.

Once however the south-west monsoon has asserted itself, the thunderstorms cease, the winds settle steadily in the west and as the season progresses, it veers gently towards the north of west, although inland it blows steadily from the south-west. As the wind strikes the coast it follows the direction of the littoral currents which at this season flow from north to south.

By the end of September the south-west monsoon dies away, nature's pendulum again begins to swing back; by October the north-east monsoon or land monsoon has usually asserted itself and with it, the rain becomes less frequent. The country begins to dry up and by the end of December, the dry weather has as a rule, set in. The period of regular land winds at night and morning, and of sea breezes during the day, then commences and lasts, till with the vernal equinox the period of disturbance again sets in.

Excessive falls of rain are quite common and floods are frequent, but as a rule floods do little damage since the rivers which have cut down deep valleys are in general able to contain all ordinary floods and the common laterite soil of the country is so porous, that within half an hour of the heaviest precipitation, the roads and grounds are all dried up. The rainfall varies from place to place very considerably and much depends upon the latitudinal position and the location with respect to the mountains. It has been shown that the lowest absolute pressure steadily diminishes from Trivandrum to Mangalore during the season of the south-west monsoon and in conformity with this, the rainfall also decreases from north to south. The highest rainfalls occur on the Anamalais and it is more or less correct to surmise that with increasing elevation, the precipitation also increases. It is particularly noticeable in the case of Mahendragiri and the Wynaad hills.[1] On the lee sides of the mountains, the rainfall diminishes very rapidly, e.g. Chinnar, Shencotta, etc. The presence of the Aramboly gap and more markedly the Palghat gap explains the diminishing rainfall observed within their vicinity. The moisture bearing winds in these cases are allowed to go into the interior and as there is no great mountain barrier to be surmounted, the precipitation is less. The vagaries of rainfall noticeable elsewhere in India are not found to any remarkable extent.

In Kerala the regions with a deficiency of rainfall are:—

(1) the three southern taluks of Thovala, Agasteeswaram and Kalkulam, which practically lie south of the Ghats,

(2) the taluk of Shencotta on the lee sides of the mountains;

[1] See rainfall map of Kerala, Journal of the Madras Geographical Association, Vol. 13, No. 2, page 131.

(3) the Chittur taluk of Cochin State and a part of the taluk of Palghat, both in the Palghat Gap.

AGRICULTURE.

Temperature and rainfall are the most important of the climatic factors which govern agricultural activity and in Kerala, where the temperatures are uniformly hot throughout the year, no particular influence of temperature can be noticed, except that the crops produced must necessarily be of a tropical type. On the contrary, rainfall is one of the prime factors in agriculture; the variety of crops cultivated and their yield per acre depend to a very large extent on the volume and distribution of rain. In Kerala, much more so than in any other part of India, the success of cultivation depends almost entirely on the reliability of rainfall and its even distribution.[1] Owing to the late arrival of the monsoons, or the unequal distribution of rainfall during the periods of cultivation, crops in some parts of the country may meet with a partial failure, but the damage caused is not so great or widespread as is often the case elsewhere in India.

Within the region of Kerala are different political units and the tabular statement given in Appendix I gives the main features of each of these parts and of Kerala as a whole. Kerala has a total area of 15,659 square miles, 10,021,760 acres; i.e., very nearly 10 million acres, of which detailed statistics are available only for 9,741,331 acres. More than one-fifth (2,031,958 acres) is forested; more than one-tenth (1,061,305 acres) is not available for cultivation; and cultivable waste other than fallow occupies more than one-eighth (1,390,079 acres) while current fallows account for about one-sixteenth (564,380 acres) of the total area. The net area sown (4,341,702 acres) forms less than 45% of the total.[2]

Forests.—Forests occupy more than one-fifth the total area, but the distribution is rather peculiar. Out of the two million acres which are forested, 1·6 million acres are in Travancore, i.e., 80% of the forests is concentrated in this region and the bulk of the remainder is in Malabar. It is found that 34% of the total area of Travancore is forested while only 10% of Malabar is clad in forest. In Cochin the proportion is still less, while that of Kasaragod is only a half of what it is in Cochin. Certain peculiarities must then account for this abnormal distribution. It is due to: (1) the difference in rainfall in

[1] This is clearly indicated by the much lower percentage of the area under irrigation in Kerala as compared to any other part of India.

[2] This compares with 40% in the province of Madras, 37% in Mysore, 14% in Coorg, 22% in South Kanara and 10% in North Kanara. It is worth noticing that the proportion of cultivated area tends to decrease steadily from south to north.

Kerala. [The total quantity may appear to be nearly the same, but there is a wide disparity in seasonal distribution. In Travancore it is much more evenly distributed throughout the year with no marked season of drought, while towards the north the dry season is about 5 months long]; (2) the greater proportion of highland in Travancore; and (3) the difference in land utilization. [Outside Travancore the punam and modan systems of cultivation of rice are very important; deforestation has been excessive with the result that the area under forest is now much less.]

As there are considerable variations in rainfall mostly in excess of 50″, Kerala is one of the botanically rich areas in India with 600 to 700 different species, probably more. 'It is impossible to demarcate this region in a botanical sense from the Deccan, for the mountains of the Ghats project sometimes far inland and carry a flora characteristic of the west, well into an area that is geographically Deccan.'[1] As early as 1903 Bourdillon noticed a similarity between the floras of Kerala and Assam, but the intervening ranges of mountains do not form satisfactory connecting links. The economically more useful trees are teak,[2] blackwood,[3] ebony,[4] sandalwood,[5] anjili,[6] thambagam [7] and venga.[8]

Within the political units differences are noticeable regarding the area classified as 'not available for cultivation'. In Kasaragod it is only 4% while in Malabar it is 4 times as much. Intermediate lie Travancore and Cochin with 8% and 12% respectively. The why of this is not clear. The statistics regarding 'cultivable waste other than fallow' seem to present still greater complications. It is 2% in Cochin, 8% in Travancore, 25% in Malabar and 28% in Kasaragod. Both in Kasaragod and Malabar, thousands of acres are shown as 'cultivable waste,' thereby making possible the inference that there is room for a great extension of agriculture, but a large part of this 'cultivable waste' is really uncultivable.[9] The figures

[1] *Field Sciences of India*, page 86.

[2] found in areas with a rainfall between 120″–150″ and at elevations ranging between 1,000–2,000′.

[3] found in areas with a rainfall more than 150″ and at elevations ranging between 2,000–3,000′.

[4] found in areas with a rainfall more than 150″ and at elevations ranging between 2,000–3,000′.

[5] found in areas with a rainfall between 20″–50″ and at elevations more than 3,000′.

[6] found in areas with a rainfall more than 60″ and at elevations less than 1,000′.

[7] found in areas with a rainfall between 100″–150″ and at elevations ranging between 2,000–3,000′.

[8] found in areas with a rainfall more than 150″ and at elevations ranging between 2,000–3,000′.

[9] Innes, *Gazetteer of the Malabar and Anjengo Districts*, Vol. 1, page 232.

regarding 'current fallows' are also suggestive. In general, it is negligibly low, 3% in Travancore and Cochin, and 7% in Malabar, but in Kasaragod it is as much as 34%. It is actually found that on proceeding northwards into the other parts of South Kanara and further north, the proportion of the area under 'current fallows' tends to increase rapidly. This is probably due to the fact that in the northern parts, the proportion of lowland is much less and the dry season is much longer. The net area sown in Kasaragod forms only 27%; it is as much as 49.5% in Cochin and 42% and 47% respectively in Malabar and Travancore.

Out of the total area of 9·4 million acres for which statistics are available, it is found that 6·3 million acres are cultivable. Of this, only 4·3 million acres are cultivated, leaving a balance of about 2 million acres in the form of current fallows and cultivable waste. Much of this land is inaccessibly situated and it may be so poor in quality that it may not respond so liberally as the land already brought under cultivation. To a certain extent these defects may be removed by developing the means of communication and by improving the methods of cultivation but it may nevertheless be taken for granted, that the additional area which could be brought under the plough, is not as great as these statistics would seem to warrant.

Irrigation.—Agriculture in India is mainly carried on with the aid of irrigation, but Kerala forms an important exception to this rule. In appendix II are given the statistics of irrigation. Although it is known that irrigation is practised to a minor extent in Malabar, no statistical information is available. The irrigated areas in Kerala are found (i) in Nanjinad in the south (with the canal systems), and (ii) in Shencotta, Chittur and Palghat (with the tank systems). In these parts the distribution and incidence of rainfall are such that irrigation becomes necessary. These regions happen to be the very parts of Kerala where there is a maximum possibility of contact with the Tamilnad with the result that the Tamil language tends to become important.[1] Is it then surprising that the agricultural methods of Tamilnad have been introduced into these parts?[2] Apparently therefore there exists a considerable amount of correlation between agricultural practices like the methods of plough-

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[1] South of Trivandrum, Tamil becomes important. In Neyattinkara 10% of the population is Tamil speaking. In Vilavankod 75%, in Kalkulam 85%, in Agasteeswaram 90% and in Thovala 99% of the population have Tamil, as their mother tongue. In Palghat, less than 25% of the people is Tamil speaking while in Kasaragod the non-Malayalee element forms about a third of the total population.

[2] Mention must also be made of the fact that Kumeri, (the equivalent of Modan in South Kanara) is cultivated everywhere in the District of South Kanara without the soil being touched by any implement of any kind, while in Kasaragod taluk alone is the land ploughed for the same as in Malabar. Vide Statistical Atlas of Madras Presidency, 1936, p. 942.

-ing, irrigation, etc., and linguistic and cultural distributions. It is also interesting to note that the Tamil element has not been able to move into the other parts of Kerala, where the conditions of rainfall and consequently agricultural methods are different from those on the east coast. The Tamilian thus seems capable of thriving as an agriculturist, only in those parts of Kerala where he finds a climate analogous to his eastern home.

In Kerala the occupied lands are generally classified as either wet lands or dry and garden lands and their distribution is as shown below:—

Region.	Wet lands in acres.	Dry and garden lands in acres.	Total in acres.
Travancore	598,897	1,948,785	2,547,682
Cochin	205,794	274,181	479,975
Malabar	496,000(approx.)	683,461(approx.)	1,179,461
Kasaragod	80,850	53,734	134,584
TOTAL FOR KERALA . .	1,381,541	2,960,161	4,341,702

It is thus seen that the wet lands constitute slightly less than one-third the total area under occupation; in the wet lands rice is practically the only crop cultivated and in the dry and garden lands are grown the perennial crops like coconut, arecanut, jack, mango, cashew-nut, etc., and some root crops like tapioca, yam, and vines like pepper and betel.

The characteristic feature of agriculture is that the tenant lives on the land because (i) the permanent crops like the coconut, arecanut, jack, etc., which are assured by the heavy rainfall of the region can be well secured only by the ryot living on the land itself and (ii) the climate and rainfall are specially conducive to the growth of trees, roots, etc., but not of rice and other cereals.

On a study of the agricultural statistics[1] of the region, it is seen that rice is pre-eminently the most important crop of the region occupying slightly less than 50% of the gross cropped area, but it is also seen that both in Cochin and Malabar the culture of rice plays a much more important part than in Travancore. In Travancore the proportion of the area under rice to the total cultivated area, is only approximately half of what it is in Cochin and the areas further north. This appears to be anomalous. Climatic or edaphic factors could not account for this; the population is essentially rice-eating, if rice could be had. In Travancore rice is mainly a crop of the lowlands, tapioca and other root crops replacing it outside the lowlands; but in the regions further north, rice is cultivated even on the

[1] Vide Appendix III.

slopes of the mountains (modan and punam systems of cultivation).[1] Heavy soils are by their nature suited to rice. This possibly explains why in general, in the coastal strips where the soils are too sandy, rice is absent. Notable exceptions to this occur at the mouth of large rivers like the Ponnani, Periyar, Pambayar, etc., due to the sediments brought down. It is only in the Ponnani valley (probably due to the low relief in the Palghat gap) that rice is cultivated right up to the eastern frontiers of Kerala.

Methods of Cultivation.—Manifold are the systems of cultivation found, but a few of them deserve special mention.

(1) *The Nanjinad cultivation* found in Thovala, Agasteeswaram and Shencotta is almost identical to the one found in the Tamil region of Tinnevelly; even the plough resembles the Tinnevelly type; here rice is almost exclusively grown under irrigation. The lands are either single cropped or double cropped. In the former sowing takes place in June-July, the seedlings are transplanted in July-August and the harvest follows six months after transplantation. The land is left fallow for the rest of the year and the yield is 15-fold. In the double cropped lands, the crops are harvested in September-October, and February-March. After the March crop is gathered, the lands are left idle for about a month or more, exposed to sun and winds. In April, the field is ploughed for the first time and the stubbles left in the previous reapings are gathered and burnt. The field is then ploughed continuously for three times and levelled with a rake. The seed should be sown before the end of April, on an average about 100 lbs. to the acre. Immediately after sowing, the field is again ploughed and smoothened. Raking should be repeated after the third, fifth and seventh days of sowing. The seed begins to sprout on the fifth day, but is generally visible only on the seventh day. The field is then exposed to the scorching sun for about 25 days when the south-west monsoon sets in, bringing large quantities of water through the irrigation canals and it is therefore true to say that the crop is dependent on the south-west monsoon. The drying should not be disturbed by falling rains during the 25 or 30 days after sprouting, as the yield will suffer materially, if rain falls during this interval. Fifteen days after water has been supplied, weeds begin to appear and these have to be removed some 50 days after sowing. About 90 days after sowing, the crop comes fully into ear and within a month it ripens and is fit for reaping. All this time, the field is kept under water about 2″ deep, till just before harvest, when all the water is drained. The yield on fair land is about 20-fold.

[1] See map showing distribution of rice in Kerala in the Journal of the Madras Geographical Association, Vol. 13, No. 2, page 134.

As soon as the September-October crop is harvested and the straw stacked, the fields are got ready for the next crop. Ploughing, raking, manuring and other operations are all done under water which has to be supplied in large quantities. It is usual to sow the seeds thick in small nurseries and transplant the seedlings to the fields got ready. Before sowing, the grain is soaked in manure and water for several hours and then put into a basket or vessel covered with straw. A little water is then sprinkled upon it and it is exposed occasionally for three days when it begins to germinate. The seeds are then sown and water is allowed to stand in the soil for a day after which it is drawn off for four or five days until the shoots have made a good start. From this time the plant requires a constant supply of water for its growth, which is served every alternate day, a couple of inches of water being allowed to stand until the time of ripening. Transplantation takes place after the crop has been about four or six weeks in the nurseries when the plant will be 10″ or 1′ in height and the seedlings are plucked and planted in the miry field. A few days later weeds appear and they are removed. Weeding takes place about three times and the plants are also thinned out to avoid overcrowding, if necessary. The ears begin to form in January and the crop is gathered in February-March. The nursery system of cultivation is highly remunerative and should be preferred to the ordinary broadcast system. 'Paddy sown yields but a fourth of that planted.'

(2) *The Kuttanad cultivation.*—(Punja system). The extent of fertility of these punja lands varies with the inundation to which they are annually subject. Fallow is essential and the area so left, serves as a reservoir of water to the neighbouring fields. The level surface is separated into blocks of 15 to 20 acres, the rank vegetation of grass and other aquatic herbs that here spring up during the rains, is removed by first scraping the bed with a long hoe and secondly by ploughing the field three or four times. This is then followed by encompassing the field with embankments which is a very difficult and tedious undertaking. The draining of the fields always submerged is a laborious process and protecting them with bund works is both difficult and anxious. A couple of ploughings are then given and the space divided and smoothed into beds. Seeds soaked in water for a period of about five days which have slightly germinated are sown broadcast. The less watery seedlings are transplanted in the vicinity of the higher ground where a few hot days are requisite to quicken the vegetation. This is accelerated by occasional inundations which are again repeated on the ninth or tenth day; the field remains overflowed for a month, then the water is drawn off for a short

time and again restored (the plant being about three-fourths covered) till the crop is nearly ripe. Kuttanad yields but one crop, reaped in the latter part of April or the beginning of May. Rice is the only cereal sown; it yields more than 20-fold. Any unexpected rise of the streams would force the slender embankments of the crops, but the regularity of the season gives a tolerable security to the farmer. Reclamations have also been made from the backwaters and the cultivation in such lands deserves notice, if only for the singular struggle of human industry against the forces of nature. From the subsidence of the floods of one year to the commencement of the rains in the succeeding year, the interval of time is rarely sufficient for the garnering of a crop. At the close of the rains, the water in the Kayals (Vembanad, Enamakal, Trichur, Muriyad, Mukundapuram) is drained off by ceaseless labour day and night, either with the indigenous type of Persian wheels or, of late with oil or steam pumps. Every foot of ground that can be obtained is protected by fences of wattle and mud and is planted up with well-grown rice seedlings. Spaces are left between the fields and into these channels, the water drawn from the fields is poured. Boats have to be employed to visit the different fields, the dry beds of which lie some 3 or 4 feet below the level of the water in the canals. With the early rainfall in April, the struggle recommences with the slowly but steadily rising floods and thousands of people continue this day-and-night struggle with the rising floods, for the preservation of their ripening crops. Occasionally the bulwarks of the fields are breached and the unmatured crop drowned. Often a large area has to be reaped by simply heading the stalks from the boats, but as a rule an enormously rich crop rewards this remarkable industry.

(3) *Nilamkrishi or Viruppu lands or Ela lands.*—(The wet lands between the Ghats and the backwaters). Cultivation begins in the middle of April, the seed being sown generally broadcast, by the end of the month or early in May. The crop matures in about four months, the harvest occurring in September. Immediately after this, the field is again turned up and prepared for a second crop, which is reaped in January. The September crop yields 12-fold, but the January crop only 8-fold. Generally the land lies fallow in February and March, otherwise a third crop of gingelly or farinaceous roots very often succeeds; they come to maturity in March and their culture is careless, cheap, and comparatively unprofitable. In very rare cases a third crop of rice is cultivated. Thus it is seen that the two crops depend upon the copiousness and even distribution of the rains of the south-west and north-east monsoons respectively. If the rainfall is excessive during the south-west monsoon, the

first crop is liable to be destroyed by flood, while the failure of the north-east monsoon tends to dry up the second crop.[1]

(4) *Mundagan lands* are those occupying the borders of the lakes of stagnant waters, but slightly elevated above the punja lands; they retain considerable moisture and yield one tolerable crop. The culture is more difficult as the soil has to be worked with a spade. Paddy is raised from seedlings sown in June and July, transplanted in August or September and reaped in February or March. The grain grown is of an inferior kind.

(5) *Kaipad cultivation.*—A peculiar feature of Chirakkal and Kottayam taluks in Malabar and the taluks of Cochin-Kanayannur and Cranganur in Cochin State is the Kaipad cultivation (otherwise known as Pokkali) practised on the low-lying lands near the coast, subject to annual inundation from the backwaters. In the hot weather the soil is heaped in small mounds about a foot in height and 5′ in circumference, on which the seeds are sown just before the onset of the monsoon. When the seedlings are about 5″ high, the heaps are dug up and the whole field levelled. The soil and the seedlings planted on the tops of the mounds thus get the benefit of passing showers without being damaged by the salt water which overflows from the backwaters during these months. When the monsoon bursts, continuous rains keep the water in the fields comparatively fresh and the seedlings can be planted out. The cultivation is precarious as an unusually high tide may destroy the seedlings and the crop is more dependent than others on the seasonal distribution of rain. The cultivation expenses are not high as there is neither manuring nor ploughing of the fields. It takes a long time to mature and the crop can generally be harvested only in October.

(6) *Malankrishi, Modan, Punam, etc.*—These are the names by which rice cultivation on the summits and slopes of hills that are cleared of trees and shrubs are generally known. Preparation for modan cultivation begins in August, although the sowing takes place only in the following April. The jungle is cut immediately after the rains and the trees and stumps are left to dry for two or three months, when they are set fire to, in February. The ashes increase the fertility. The ground is rudely turned up sometimes with a peg, more generally with a hoe, but with a plough only on the lower slopes, where it may be ploughed as many as twelve times. The seed is sown with ten times its own weight in ashes and cowdung. The fields have to be strongly fenced for protection from wild animals and rabbits. The weeding takes place only after the 40th day and the

[1] In Malabar the September-October crop is generally sown broadcast and the seedlings are planted out for the January-February crop. The former crop is weeded once, the latter not at all.

gathering of the crops is done about 140 days after they are sown, i.e., in September. The cultivation can be repeated in the year to follow, but the land becomes infertile afterwards. If the crop is not repeated, gingelly is sown and harvested in December or January. The samai crop which is not of great value is raised in the following May or June and the land is allowed to lie fallow for 2, 3, or 4 years according to its fertility. It has therefore got to be a migrating cultivation. The chances of getting or losing the crop are equal. The ryot mainly calculates upon the conserved energy of the soil which has lain fallow for nearly 12 years. Modan is thus grown on the low hills which abound in all those parts, north of Travancore. The rotation is generally modan, gingelly and samai, but on the best lands a ginger crop frequently precedes the modan.

In the limited space at my disposal, I have tried to give in some detail the various methods practised by the ryot, to bring under the plough all those parts which he could possibly manage to, the kuttanad cultivation, the kaipad cultivation and the malankrishi being specific examples. It is well nigh impossible to suggest an increase in acreage to augment the present production.

Yield.—The average yield of rice in Kerala is 540 Madras measures per acre; in North Arcot it is 800. This low yield is due to several factors the most important of which are the following: (i) The principal crop, that of September-October, is hardly in the ground for 4 months. (ii) Poor crops are often raised at a minimum cost on terraces high up above the double crop lands. (iii) The standard of cultivation is lower than on the east coast, because there is a considerable amount of overcropping without fallow and the wastage is not replenished by manure. (iv) Under the influence of unfailing rains, the soil responds too readily to inefficient cultivation with moderate crops and the ryot's wits are not sharpened by a constant struggle against nature.

Other cereals.—The area under cereals other than rice is negligibly small. Cholam is found in the southern taluks adjoining Tinnevelly and in the drier parts of Palghat taluk, especially in the black loamy soils. Ground is prepared about April-May and sowing takes place a month later. The crop is dependent on the rains, but a light rainfall is sufficient and the crop matures in four months. No nursery is required and the straw makes very good fodder. Under a suitable system of irrigation, ploughing and manuring, several crops can be raised from the stalks of the same plant.

Coconut.—In Kerala, the cultivation of the coconut palm forms one of the most important features of agriculture. Slightly less than one-fourth the gross cropped area is under coconuts and as a crop it is second only to rice. None of the other oil seeds are cultivated to any large extent as to deserve mention. The most porous of soils could be used for the cultivation of coconuts, if water is available. The best soils are naturally those of the deep alluvial plains, but it has been found that sandy shores are very suitable, because they have behind them higher country and the rain which falls in this higher country sinks in the soil and moves towards the sea, carrying with it food which it dissolves as it moves. It is moving water in the ground which is primarily responsible for the high development of the tree on the shores of the sea and backwaters. Therefore the country sloping from the sea upward, even for great distances, makes good coconut country, so long as there is still higher country lying behind from which a supply of soil water can be derived, e.g., Kanjirappally, Minachil, Pathanamthitta, etc. Of course in these cases, the cost of transport is too heavy for the cultivator to derive any benefit from the husk which generally goes to waste. The widespread belief that coconut needs salt water for its development does not seem to be true. The sea beach, even though it be beside the ocean, is found to be as free from salt as the land which lies above it. The coconut roots can endure salt, but this does not mean that it either wants it or can make use of it. Based upon the variety and the enormity of the uses to which its products are put, it is not untrue to say that the rural economy of Kerala depends on this tree.[1]

Tapioca and other root crops.—These crops are mostly found in the region of the foot-hills. Tapioca is a plant that thrives in the poorest of soils like laterite, despite gross neglect on the part of the farmer. A moist climate is essential. The cuttings are generally planted during the two monsoon seasons, usually on heaps of earth with trenches around for the water to gather and flow away. The crop matures in 9 to 11 months and gives a net income of about Rs.75 per acre. It is only of late that its culture has proceeded north of Travancore into Cochin and Malabar, but it is regrettable that detailed statistical information is not yet available. It forms a staple food especially of the poorer classes; it supplements but does not supplant rice. Along with tapioca, other root crops like yam, chembu, chena, etc., are cultivated; besides, plantains of different types are also cultivated.

Plantains are widely distributed and found almost in every household; the most suitable soils are those in which sand and clay are mixed together. The low banks of rivers with an annual silt deposit forms the best soil. It grows almost anywhere without much care and about 500 of them can be planted to the acre. All the varieties other than the banana should be planted in March-April, while the banana

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1 'Industrial Crops of Kerala', the Journal of the Madras Geographical Association, Vol. 11, No. 4, pages 284 to 286.

should be planted two months earlier. The period of fruiting follows about 11 months later. As little or no time is involved in its culture, the ryot in addition to his wages gets an average income of Rs.70 to 80 per acre in the year.[1]

Ginger.—The suitable soil is one which is free from gravel and is good and heavy. Rain is essential, but superfluity of rain must be avoided. The ground must be ploughed to a depth of one foot during the latter part of December; in March-April, the ground has to be slightly turned and harrowed. Cultivation begins at the commencement of the south-west monsoon, the plant matures in about 8 to 10 months. Its culture requires considerable amount of care and intensive manuring. The average yield is 20-fold and the profit per acre varies anywhere between Rs.80 to Rs.150. Ginger is usually cultivated in small patches, not more than half an acre in extent and the labour expended on it is generally that of the cultivator and his family.

Pepper was one of those commodities which played a very important part in the trade of the Roman Empire with the East.[2] Kerala practically enjoys a monopoly in the production of pepper and the well-being of the people of Kerala has been described as having been pickled in pepper for the last 2,000 years.[3] There are no pepper estates at all and it is grown with many other crops in most of the households. The statistical information given about the crop can at best be only a rough approximation. It requires a hot moist climate, more than 100″ rainfall. Copious rain is essential in the blossoming season between the 20th of June and the 5th of July but in the 3 months before picking (the gathering season is from January to March), a heavy downpour injures the soft pulpy berries. In July-August, and in October-November, the soil of the garden is turned up with a hoe and plantains are cultivated between the props to provide shade for the growing vine. Subsequently the crop requires little attention. Manuring is not generally resorted to in Kerala.

Betel vine.—Black sandy soil is the best suited for its cultivation, the soil being a rich mixture of sand and clay. It will not grow in elevated places. Although it involves a good deal of labour, it is still a very profitable crop and forms the most important by-product like pepper, especially in Trivandrum, Mavelikara and Shertalla. Watering has to be done at least for 4 to 6 months in the year, and in the hot weather

[1] In Cochin, the average income per acre of banana cultivation is about Rs.100 but it requires more care and in some cases there is a need for irrigation.

[2] Warmington, 'The Commerce between the Roman Empire and India'.

[3] M. E. Watts, *Asiatic Review,* 1930.

as frequently as twice a week. In the monsoon months, the vine is most fruitful.

Areca palm is indigenous to Kerala. It grows most luxuriantly in stiff clayey soils and hence is always found in the banks of rivers, canals and low valleys. About 500 to 800 palms can be cultivated in an acre and it requires little or no attention. It yields three crops in January, February and March, giving an yield of about 300 to 350 nuts per plant and is thus a very profitable crop. The price of the nuts varies very considerably, but even on a conservative estimate, the annual yield per acre is about Rs.300 to Rs.500.

The plantation crops of rubber, tea and cardamoms [1] are found mainly in Travancore. Rubber is typically a foot-hill crop grown in areas where the elevation varies from 700′ to 1,000′ and the rainfall between 80″ and 120″. The yield is only about 300 lbs. per acre and is approximately half the yield in Ceylon and one-third that of Java. Because tea demands copious rains and complete drainage, only hill slopes are generally suitable for the cultivation of tea. Outside Travancore, it is only in Wynaad that some tea is grown. It is only in Devicolam that there is high grown tea (4,000′ to 5,000′), while elsewhere it is medium grown (2,500′ to 4,000′). On an isohyetal basis, it is true to say that tea is grown only in those areas where the precipitation is in excess of 100″, generally 150″. The yield of tea is about 500 to 800 lbs. per acre. Cardamom is also another crop found on the higher reaches of the Anamalais, the optimum elevation is 3,000′ to 3,500′, but it is grown in areas between 2,000′ and 4,000′. As it cannot stand wind, the best crop is obtained in sheltered ravines and hollows. The total quantity of rainfall does not seem to be fundamental (60″ in Ceylon and 175″ in Travancore) but what is of the highest importance is, that there should be a few good heavy showers to thoroughly moisten the soil between the middle of January and the middle of May. A long hot dry season always means a bad crop. A heavy south-west monsoon is considered favourable. The yield ranges from 100 to 200 lbs. per acre.

Besides the aforementioned crops, there are several others like cashew nut, jack, lemon grass, pulses like black gram, green gram, etc., and it would be impossible in the short space at my disposal, even to give some passing mention of these. I have already tried to indicate the variety of crops cultivated, together with the agricultural practices of this region and some mention must now be made of the crop associations prevalent therein.

On a talukwar analysis of the proportion of the cultivated area to total area, it is found:—

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[1] The Journal of the Madras Geographical Association, Vol. 12, No. 1, pp. 1–8: G. Kuriyan, 'Industrial Crops of Kerala'.

swaram, rice is fundamentally more important. In Kunnatur and Changanacherry the root crops have together an area more than 40% of the gross cultivated area and they exemplify the characteristic foot-hill cultivation in Travancore. Is it therefore true to conclude that as the proportion of lowland diminishes, the extent of area under coconut decreases more rapidly than that under rice? Apparently it is so;

(iv) that taluks in which the cultivated area is between 20 and 40% of the total area (Thovala, Kalkulam, Nedumangad, Kunnathunad, Chittur, Chirakkal, Kottayam in Malabar, Ernad, Walluvanad, Shencottah, Thodupuzha and Kasaragod) lie in general outside the lowlands.[1] It is surprising to notice that in spite of the poverty in lowlands, in general, rice dominates as the main crop; coconuts together with the roots and vegetables occupy about one-third the total cultivated area. Such however is not the case in Travancore. In Nedumangad the root crops together account for 80% of the cultivated acreage; but it is not so great either in Thovala or Kalkulam, probably because of the difference in the nature of agriculture due to irrigation, but nevertheless the distinction between the type of agriculture in the northern parts of Kerala and the south is clear. The effects of the northern type as has already been shown, are found even as far south as Muvattupuzha and Kunnathunad in north Travancore. It seems justifiable to conclude that the agricultural practices in the north and the crops cultivated are such that only the rice lands are being fully utilized. The foot-hill zone of laterites is not being tapped to its fullest extent;

(v) that those taluks in which the cultivated area is less than 20% of the total area lie either entirely in the highlands as in Devicolam, Peermade and Wynaad, or have the bulk of the area in the highlands with about 10% of the area in the foot-hill zone as in the case of Pathanamthitta. It is found that as the area under the foot-hill zone increases, the percentage of cultivated land to total area, correspondingly increases. Devicolam, Peermade and Wynaad are the only taluks which are completely in the highlands and

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in these only about 10% of the total area is cultivated. In Devicolam and Peermade, the entire area cultivated is under plantation crops (85% tea, 10% rubber and the rest under cardamoms) while in Wynaad, in spite of the elevation, rice is the most important crop occupying more than half the cultivated area; tea claims only one-fifth the acreage and coffee one-tenth. This is partly due to the lower absolute elevation of Wynaad, but also to a certain extent depends on the lower standards of agriculture in Wynaad.

Thus, if a classification on a talukwar basis is adopted according to the extent of the use of land, one finds that but for very few exceptions the extent of cultivated acreage directly depends upon the nature of the taluk and its position with respect to the natural regions to which Kerala has been divided. As the proportion of lowland within the area of the taluk increases, the percentage of cultivated land increases in a direct ratio, and as the proportion of highland increases, agricultural utilization tends to diminish. The physical regions based on contours and soils then, tend to delimit land utilization. As agriculture is pre-eminently the most important occupation, it seems true to conclude that these physical regions also delimit economic regions.

In our study of regions we are particularly concerned with the interaction between the physical and biological conditions on the one hand and the nature of the human response on the other. An attempt must be made for classification into regions which will facilitate this study. The major regions in a vast subcontinent like India are constituted by a harmonious but complex combination of many different elements, but the smaller regions within them are generally distinguished by the prevalence of some particular characters or relations. The West Coast of India is definitely a unit in the vast subcontinent of India and in it are the smaller subregions of Kerala in the south and the Konkan region further north. In the former are three different natural regions of the 'pays' class, each of which tends to develop the type of rural economy most appropriate to its particular climatic and edaphic conditions; a physical unit tends to be an economic unit and the more developed the means of communication, the more pronounced is regional specialization.

POPULATION.

I have elsewhere shown[1] that Kerala is one of the most densely peopled parts of the world. In an agricultural region

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like this, the factors that govern the density of population are chiefly those concerned with the cultivation of the crops and the distribution of the produce. Rainfall seems to have very little influence directly on the density; the highest densities are found in those parts where the rainfall is about 90 to 100". The nature of the soil and its fertility have a direct bearing on the kind of crops cultivated. It has already been shown that the lowland division of recent sediments is a rice-coconut region, the lateritic foot-hill zone is one in which the root crops tend to predominate together with rice and coconuts and in the highland zone, the plantation crops are the most important. It is found that the density of population varies directly as the extent of rice cultivation, particularly so in those parts of Kerala lying to the north of Travancore. The variation in density however is not quite proportional to the area under rice. Rice which is the staple food of the people is cultivated most extensively in the lowlands; coconut, the chief money crop, is cultivated here more extensively than elsewhere, and the chief cottage industry of coir yarn is almost exclusively confined to this tract. Fish which is an important supplement to rice in the dietary of the majority of the population is more abundant in this tract due to the proximity to the sea and the backwaters. Owing to these circumstances, the population which a square mile of land in the lowland division can support is considerably more than the proportion of cultivated area either to the total, or the cultivable area, would seem to warrant. Again the lowlands with the cheapest forms of transport have the highest densities and the highlands with the least accessibility have the lowest densities.

A close connection seems to exist between the density of population, the proportion of the cultivable and the cultivated lands and the kind of crops cultivated.[1]

Division.	Proportion of cultivated to total area.	Density of population per square mile of total area.	Density of population per squar mile of cultivable area.
Lowlands . .	75 to 80%	About 1,750	About 2,000
Foot-hills . .	65 to 70%	,, 900	,, 1,000
Highlands . .	Less than 15%	,, 80 to 100	,, 200

The proportion of cultivated area to total area or cultivable area is only about 10% greater in the case of the lowlands than in the case of the foot-hill zone, but the density is nearly twice as much in the former than in the latter. 'The various industries

[1] Figures are based on the 1931 census. Accurate statistics are published only in Travancore. The others are approximations.

in connection with the coconut palm, the rich fisheries of the sea and the lagoons, and the multifarious occupations of a commercial and maritime tract, can afford to maintain in a fair degree of comfort a population so densely packed that it must inevitably starve in less favoured regions.' [1] Besides rice, tapioca is an important item of food and it is most extensively cultivated in the foot-hill zone. Although in comparison with the lowlands, the foot-hill zone produces less rice and coconuts, it specializes in the production of the root crops, fruits, vegetables, pepper and rubber. Hence the density of population is less than in the lowlands, but decidedly greater than in the highlands. The highlands contain the least proportion of food-crops, but it specializes in the plantation crops of tea and cardamoms, but these are mostly in the hands of the European planters. Consequently, although the opening of these estates has increased the proportion of cultivated land to the total and the cultivable area in the highlands, it has not correspondingly increased the number of persons supported by agriculture. Between the foot-hill zone and the highlands, the variations in density correspond almost exactly with the variation in the proportion of the area under food and money crops (excluding rubber and tea) to gross cultivated area.

A correct idea of the number of persons a particular tract can support and is now supporting can only be had by a study of the densities on the cultivable and the cultivated lands. In the lowlands, more than 90% of the cultivable land is being cultivated, while in the foot-hill zone and the highlands the respective proportions are 80 and 40.

Region.	Density of population per square mile of cultivated land in			
	Travancore.	Cochin.	Malabar and Kasaragod.	**Kerala.**
			Approximate	More than
Lowlands ..	2,186	2,733	2,000	2,100
Foot-hill zone ..	1,303	1,126	1,000	1,000
Highlands ..	591*	365	400	400

* Notice the much higher density in the highlands of Travancore.

These figures more or less show that the lowlands have reached the highest point, perhaps even exceeded it; there seems to be some scope for the absorption of the population in the foot-hill zone, where about 20% of the cultivable land

[1] Census of India, Cochin, 1931, Parts 1 and 2, pages 11 and 12.

is still available for cultivation. There is decidedly much better scope for the accommodation of a larger population in the highlands where the density on the cultivated land is low; and where about 60% of the cultivable land is still available for cultivation. The number of persons a square mile of cultivated land can support varies directly as the proportion which the land cultivated with ordinary food and money crops bears to the gross cultivated area, provided there are no disturbing factors, such as the existence of industries or the availability of other sources of food supply like fish, or the cultivation of plantation crops like tea and rubber which benefit the foreign investors more than the indigenous population.

Recent estimates have shown that in Germany, every man supported by agriculture cultivates 2 acres of land, in France 2·3 acres, in Italy 2·4 acres, and in Belgium 1·7 acres giving an average of 2·2 acres per head of population supported by agriculture. The corresponding world estimate is 2·5 acres.[1] In 1931, the total population of Kerala was 10·14 millions of which 3·98 millions were supported by agriculture. The total cultivated area was about 4·3 million acres. Since then the population has increased by about 20% approximately[2] and as no large venues of employment have come into existence since 1931, it is estimated that the population dependent on agriculture at the present day is about 4·75 millions. There has been no increase whatever, in the area under cultivation. A very conservative estimate thus shows that at present each person supported by agriculture has about 0·9 acre of land. It may be argued that the nature of the land and the tillage in Kerala are entirely different from those in Europe, due mainly to the fact that double and treble cropping is possible here, while such is never the case in Europe; yet in point of acreage, Kerala is much worse off than most of the European countries. It is slightly better off than Japan in regard to the average area of cultivated land per head of the total or agricultural population. But the outturn of crops per acre in Japan is at least four times that of Kerala and the Japanese have industrialized themselves to an enormous extent in comparison with Kerala, which results in bringing a not inconsiderable subsidiary income to the community at large. Neither the increase in the yield of crops, nor the acreage under cultivation has actually kept pace with the growth of population, with the result that the pressure on the land is now much greater.

The development of local agriculture by extending the area under cultivation and by improving the methods of farming

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[1] Edward M. East, Mankind at the Cross Roads, page 70.

[2] In Cochin the increase is 18·1%, in Travancore, Malabar and Kasaragod the exact figures have not yet been made available. A press notification dated 28-10-1941 states that the population of Travancore is 6 millions showing an increase of 20%.

will increase the means of subsistence and enable the country to maintain a larger population on a better standard of life. Out of a total cultivable area of 6·3 million acres, about 2 million acres including 'current fallows' and 'culturable wastes' still remain uncultivated. Much of this however is so poor in quality or so inaccessibly situated that it will not respond so liberally as the land already brought under cultivation. These defects may be removed to some extent by the development of communications and it is probable that such new lands will be able to support a density of about 600 persons per square mile on the present standards. The maximum population capacity of the whole region should be somewhere in the neighbourhood of 12 millions. During 1921–1931, the population increased at an average rate of 2·16% per annum and if it has continued to increase at about the same rate since then,[1] the saturation point has already been reached. What solution can then be offered for feeding these increasing millions ?

Conclusion.

As has already been shown, it would not be generally advisable to encroach upon the reserved forests to increase the area under tillage, particularly as the maintenance of these forests is essential in the interests of rainfall and consequently of agriculture itself; and every attempt must be made to conserve the soil which would otherwise be completely denuded away by the torrential rains of this region.

The solution to this problem is by no means easy. The obvious remedy that one can suggest is an attempt at a conscious check on the growth of population by practising the principles of birth control. To profess this is easy, but it is very doubtful if it could be brought into practice in any part of India due to a host of factors.[2] Nor is emigration easy. Internal migration from the thickly populated to the sparsely populated parts within the region is taking place, but not to such an extent as to afford substantial relief to the congested lowlands. The scope for external migration is very much more limited; to regions outside India (Burma, Ceylon, etc.) it is almost impossible. In the adjoining province of Madras, the Malayalee is looked upon as an intruder, who is by no means welcome. The next alternative is to suggest industrialization so as to bring in a subsidiary source of income to the community at large. With the development of the Pallivasal hydro-electric power scheme and the consequent supply of cheap power throughout Travancore and Cochin, some industries will naturally develop. Malabar could be supplied by Pykara,

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[1] See footnote 2, p. 30.

[2] Vide Census of Travancore, 1931, Part I, Report, pp. 46-47, where Dr. Kunjan Pillay gives his considered opinion of this problem.

once the Papanasam project comes into operation. Most of the industries themselves will indirectly depend on agriculture, the coir and associated industries perhaps will continue to retain the predominant place; rubber industries, wood industries, paper manufacture, etc., are all possible; but it is my considered view that these are not likely to solve the problem of poverty in any part of Kerala. With its very limited mineral resources, India has little chance of becoming an industrialist and Kerala is no exception to this. The development of industries will alleviate the suffering, but it may not in itself be able to cure the ailments. Agricultural improvements are certainly called for, and perhaps they are the fundamental sources which are likely to yield results of a more permanent value.

The time-honoured method of suggesting improvements is the recommendation that western methods should be practised. The western methods cannot be transplanted due to the size of the holdings in Kerala. About 10% of the holdings are less than 50 cents, 38% less than 1 acre, 87% less than 5 acres and 96% less than 10 acres. In any country, the size of an economic holding varies with the standard of living and the type of crops cultivated, but for a family of five in Kerala, the estimated figure is about 5 to 8 acres.[1] Hence nearly 90% of the holdings are uneconomic. In addition the ryot is ailing from chronic indebtedness. What is actually needed is a new outlook on agricultural enterprise among the governments and the landed aristocracy in the region. They should press into service the help of science in the agricultural industry as freely as it is done in the case of all other industries. It is indeed a pity, nay a tragedy, to think that the owners of an industry that is giving employment to the 300 out of the 400 millions of India's population have not, generally speaking, taken advantage of what science has shown to be possible in its development. All other industries put together in India, could never hope to give employment to such a vast population as the agricultural industry does today. Yet, it is the most unorganized industry.

The possibilities of increasing the acreage under tillage are admittedly few, the chances of improving the size of the holdings to make them more economical are perhaps fewer. Yet another method of looking at the problem would be to try and determine the extent of employment which the ryot actually has at present, to find out if he is fully occupied during the 12 months of the year; and if he is unemployed to suggest some suitable sources of employment for him, either industrially or agriculturally. I have not made a sufficiently intensive study of the industrial potentialities of the region, but apparently they do not seem to be very great and the chances of such industries removing

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[1] Vide 1931 Census of Travancore, Part I, page 46, where the figure suggested is 10 acres.

unemployment on a large scale, are to my mind remote. I am however prone to suggest that if the agricultural ergographs [1] are constructed, either for the region as a whole, or for the three natural regions into which it has been divided, one notices certain remarkable features. There is the absence of satisfactory employment during the months of May, June, July and August in the bulk of Kerala.[2] This season of agricultural inertia with its incessant rains also happens to be the season of poverty in coconuts. It is mainly during this season that the agricultural population requires employment. On the coastal regions it is possible to suggest the remedy of fishing to a certain extent, but it must be admitted that this is again the one season when the seas are really stormy, so that fishing is most dangerous. Unless modern methods of fishing with trawlers are adopted, it is not likely that fishing could develop remarkably in this season. And even if it does develop, it would provide occupation only for the coastal peoples. Admittedly the coastal lowlands are the most densely peopled parts and relief there is more pressing than anywhere else, but nevertheless, attempts should be made to secure something which is likely to benefit the whole of Kerala. The suggestions which I venture to put forward here are of two types: (i) a more intensive type of cultivation of the several crops now grown in the region, and (ii) the introduction of new crops.

The area under betel leaf and arecanut cultivation could be increased. At the present day there is an enormous demand in India for both these commodities. With fast transport, and who knows electrically cooled railway carriers, it would be possible for this region to cater to a very large part of India's demands on the pan industry. Fruit trees like the bread fruit tree could be grown in larger numbers in the home gardens and an attempt must be made to promote the culture of the jack tree. Robusta coffee has been introduced into the foothill regions of Travancore recently. As a garden crop its cultivation has been very successful. I do not advocate the growth

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[1] For a detailed discussion of these ergographs see Dr. A. Geddes, International Congress of Geography, 1938, 'The Chotanagpur Plateau and its bordering plains'. I must here express my most profound thanks to the Director of Agriculture, Madras, for the trouble he has taken on my account, in obtaining for me the full details of agricultural activity in Malabar and Kasaragod. I regret, that in spite of repeated requests no information of any sort was available from the Department of Agriculture in Travancore. It is a pity that I should be informed by the Director of Agriculture of so enlightened a State as Travancore that the information asked for—'the activity and life of the normal ryot in characteristic villages in Travancore'—is not available!

[2] Except in Nanjinad in the south where the first rice crop is then grown under irrigation. Perhaps it is best to construe this as a region of transition between Kerala and Tinnevelly. In Kuttanad, May is a busy month because of the onset of the monsoon when the water has to be kept at bay and the harvest has to be gathered.

of coffee estates, as it is not likely that such estates in Kerala could compete with those of Coorg or Mysore, but as a garden crop of the foot-hill zone, it will be very advantageous and sufficient to meet the home demands. Black gram and green gram are found to grow luxuriantly in soils with a limey constituent, mainly in the less leeched soils of the south. These are sown in March-April, to be harvested in June-July. A second sowing takes place in October-November with the harvest in December-January. The cultivation of these pulses, fruits and vegetables is generally done during the period of agricultural inactivity; it is therefore true to some extent to say that agricultural unemployment is less in those parts where the variety of crops is greater, as in the foot-hill zone of Travancore.[1] Parts of Kerala lying further north would do well to emulate the agricultural practices of the south. The extent of the area under the pulses should be increased and other pulses like the soya bean should be introduced. According to Decandolle, the soya bean is indigenous to Cochin-China and Java. In Manipur and Naga hills, it is sown in November or December and harvested in March or April. Is it impossible to evolve a type of soya bean which would grow under the climatic conditions of this region? On the calcareous soils, fodder crops like alfalfa or lucerne can be cultivated to great advantage.[2] Other crops like cheena, buckwheat cowpea, etc., could all be grown in the region. Buckwheat is grown in Darjeeling hills and in Bihar and Central Provinces. Sown at the end of June in roughly prepared land, it is harvested in October. Since the seed sheds easily when it is ripe, an early harvesting is necessary. It grows best on granitic soils and it is scarcely ever manured. As such it is most suitable for the hillier parts of north Kerala. It is a very nourishing grain and is specially appropriate for feeding hens, as it induces them to lay eggs earlier. It should always be utilized as a catch crop. Lac culture is possible, especially with turmeric and ginger being grown under the shade of the trees. The inoculation can take place in November or December and the crop harvested in June or July.

'It even required the exercise of the autocratic powers of Fredrich II of Prussia to effect the introduction of the potato into the sandy districts of Pomerania and Silesia.'[3] Likewise, it required a Napoleon to introduce beet-root into France. Some revolution in agricultural methods and crops is necessary, if the region is not to suffer from poverty and pestilence, and

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[1] Compare the graphs X and XI.

[2] Statistical Atlas of the Madras Presidency, 1936 edition, page 913. 'The remedy lies in the growth by the ryots themselves of fodder crops in the dry season.'

[3] Chisholm, 'Commercial Geography,' page 135.

it is high time the governments, enlightened as they are, should become emboldened to attack this problem of land utilization and pressure of population, from an angle not hitherto looked at. A land utilization survey should be conducted and its results would be of far-reaching value. I may be considered to be an arm-chair theorist with no concept of the conditions in the field and the difficulties associated with agricultural propaganda among the uneducated millions of India's peasants to make such sweeping suggestions. Kerala has the highest standard of literacy in India, both among men and women, and it would therefore be the very region where agricultural reforms are easiest. I submit that these facts, however theoretical and unorthodox they may appear to be, deserve some consideration at the hands of the administrators.

APPENDIX I.

	Area.	Forests.	Not available for cultivation.	Cultivable waste other than fallow.	Current fallow.	Net area sown.
Malabar	3,591,675	357,949	600,087	862,866	256,031	1,514,742
Travancore .. .	4,714,985	1,593,925	363,161	371,816	117,158	2,220,350
Cochin	944,053	59,810	76,995	11,463	23,648	472,026
Kasaragod	490,618	20,274	21,062	143,934	167,543	134,584
Total for Kerala .	9,441,220	2,031,958	1,061,305	1,390,079	564,380	4,341,702

APPENDIX II.

Region.	Total area irrigated.	Canals.	Tanks.	Wells.	Other sources.	Rice.	Crops, cereals and pulses excluding wheat, barley, jowar, bajra, maize.	Other food crops.
Kasaragod	..	..	..	..	..	..	..	..
Malabar	..	..	..	..	..	..	..	..
Cochin	344,579	188,064	20,937	14,725	120,853	213,090	25,033	45,827
Travancore	814,720	303,399	114,536	10,432	386,353	..	431,105	320,309
Total ..	1,159,299	491,463	135,473	25,157	507,206	213,090	456,138	366,136

APPENDIX III.

Name of Taluk.	Total area.	Total cultivated area.	Area under								
			Rice.	Coconut.	Tapioca.	Sugar-cane.	Rubber.	Tea.	Coffee.	Pepper.	Ginger.
Thovala ..	92,774	29,483	14,127	480	1,414	10	..	387	65	..	..
Agasteeswaram ..	68,228	33,073	24,762	8,241	70	..	..	..	..	..	..
Kalkulam ..	146,810	51,975	20,480	12,342	15,510	1,150	1,176	820	..	213	234
Vilavankod ..	105,702	49,743	8,494	17,886	14,762	50	2,341	..	..	111	99
Neyattinkara ..	149,344	95,284	14,912	31,416	48,508	..	..	..	..	311	137
Trivandrum ..	62,246	41,996	10,010	22,785	8,485	..	75	..	..	635	6
Nedumangad ..	234,253	91,470	14,096	7,694	46,275	..	2,418	2,746	..	18,225	16
Chirayinkil ..	93,760	61,732	13,504	28,588	18,157	..	..	..	..	1,513	..
Quilon ..	94,342	75,539	14,611	49,885	10,038	..	..	..	..	..	..
Kottarakara ..	129,299	90,366	16,791	26,427	37,038	33	685	..	..	6,387	5
Pattanapuram .	272,429	63,818	12,580	5,294	27,341	416	7,477	3,131	..	4,520	59
Shencotta ..	72,650	15,674	7,729	1,109	6	3	2,727	1,050	50	..	..
Pathanamthitta ..	574,822	82,175	8,209	20,668	29,575	1,847	12,193	3,365	..	3,272	46
Thiruvella ..	140,896	116,025	32,198	43,150	38,510	6,546	1,221	..	..	1,400	10
Kunnatur ..	96,294	48,319	14,289	9,629	14,180	28	4,113	400	..	3,029	14
Ambalapuzha ..	94,374	80,933	54,118	23,762	53	..	..	..	..	..	..
Kartikapally ..	46,514	43,945	24,686	16,259	..	..	..	..	..	..	..
Mavelikara ..	71,115	69,791	21,972	19,070	25,553	130	66	..	..	..	..
Karunagappally ..	56,960	51,906	21,197	23,818	3,789	..	..	..	..	13	27
Changanacherry ..	168,819	102,151	31,647	23,347	17,540	969	24,917	1,531	..	..	..
Kottayam ..	133,986	99,858	36,772	27,175	20,086	1,364	4,495	..	..	4,238	2,028
Shertallai ..	74,970	61,555	22,145	34,941	269	..	..	..	..	..	..
Vaikom ..	92,198	69,512	26,682	22,831	11,472	..	772	..	..	..	..
Minachil ..	181,382	130,806	16,587	58,875	12,542	205	11,956	1,030	4,082	15,367	7,062

APPENDIX III—*continued.*

Name of Taluk.	Total area.	Total cultivated area.	Area under								
			Rice.	Coconut.	Tapioca.	Sugar-cane.	Rubber.	Tea.	Coffee.	Pepper.	Ginger.
Muvattupuzha ..	279,974	130,095	75,113	9,823	25,130	212	5,975	..	297	5,361	4,684
Thodupuzha ..	311,642	80,077	31,166	9,986	11,549	45	6,284	780	483	15,261	1,523
Kunnathunad ..	231,462	74,081	63,535	817	1,400	105	1,673	..	..	1,953	1,098
Parur ..	62,595	61,990	34,404	19,067	2,295	1,400	138	..	..	..	..
Devicolam ..	426,899	38,827	3,107	..	..	12	783	33,611	914	..	..
Peermade ..	288,576	35,235	303	5	..	..	5,261	29,095	..	..	..
Cochin Kanayannur	101,423	75,360	32,115	25,400	5,400	..	..	..	..	..	..
Cranganur ..	11,209	9,454	2,382	6,495	520	..	..	..	..	..	..
Mukundapuram ..	322,247	116,123	57,163	18,439	14,060	..	5,000	970	66	1,654	..
Trichur ..	156,736	87,735	50,503	9,250	6,606	..	2,000	..	..	..	..
Talapalli ..	163,946	115,565	71,281	3,165	3,216	..	..	..	..	..	..
Chittur ..	188,492	64,005	52,180	1,610	3,260	340	3,000	1,627	2,066	440	..
Chirakkal ..	436,271	168,767	87,443	39,513	21,290	26	..	..	..	33,063	57
Kottayam ..	308,032	106,891	34,878	39,917	16,419	..	182	..	..	23,892	38
Kurumbranad ..	323,456	188,775	53,861	103,348	10,022	..	2,003	..	3	9,090	682
Wynaad ..	524,831	74,969	40,080	..	9,463	5	470	12,295	4,345	8,035	367
Calicut ..	242,477	110,037	40,125	40,442	7,236	..	2,955	..	168	5,698	719
Ernad ..	618,496	201,927	110,412	37,372	12,519	..	5,072	430	..	5,451	3,669
Walluvanad ..	562,045	201,036	156,088	17,236	12,057	..	1,544	51	342	6,742	4,060
Palghat ..	411,539	204,931	207,445	10,807	9,126	23	900	124	1,397	291	677
Ponnani ..	272,093	219,766	129,906	64,593	4,055	1	..	..	..	1,756	1,061
Cochin ..	11,158	897	190	598	..	..	..	..	..	..	..
Kasaragod ..	490,618	161,685	106,950	21,500	..	..	..	..	..	6,050	..
Total for Kerala	10,010,098	4,314,462	1,923,228	1,015,020	441,547	15,489	119,872	93,083	14,543	86,416	34,091

SECTION OF BOTANY

President :—N. L. Bor, M.A., D.Sc., F.L.S., F.N.I., I.F.S.

Presidential Address

(*Delivered on Jan. 4, 1942*)

ECOLOGY: THEORY AND PRACTICE

Contents.

Introduction.

It is immaterial for the consideration of our subject whether ecology, the youngest but, nevertheless, one of the most vigorous branches of biology, had its origin in a work of Humboldt's published in Paris in 1877 (De destributione geographica plantarum) or in the writings of Möbius (1883) or Häckel [1] (1866) or whether we have to go back to the beginnings of the Christian era or even earlier and search for indications in Lucretius (vide Tansley) or in Charaka [2] (vide Chaudhuri). Whatever may have been the origins, it was Häckel, incidentally a zoologist, who first put forward a definition of ecology. He described it as 'the science treating of the reciprocal relations of organisms and the outside world'. He meant thereby that the subject includes the study of the various reactions and coactions of living organisms, plant and animal, upon one another and upon the terrestrial environment: the study of everything operating as an influencing factor within the abode or habitat: the study of the origin and development of the structure of the living community together with that of the living organisms which are an intricate part of it.

Although Häckel was a zoologist and was speaking as such, the definition of the subject shows that ecology in the wide sense concerns any study which embraces the relations existing between a living being and its environment. This means, of course, that the science is applicable to plant as well as to zoological (including human) problems. The universal application of ecology has been ably stressed by F. M. Smuts, the exponent of holism and inspiring leader of the South African people, in the following words: 'Ecology must have its way; ecological methods and outlook must find a place in human government as much as in the study of man, other animals and plants. Ecology is for mankind' [3].

It is clear, of course, that we cannot divide up ecology into small watertight compartments and label them plant ecology, animal ecology, social ecology and so forth and treat them as isolated and independent subjects for study. All sections are more or less directly or indirectly interdependent. Moreover, it will be observed that the abode or habitat in which the organisms live must also be considered. Thus an investigator, who is a specialist in one biological science, is dependent to a large extent for his environmental data upon the work of specialists in other subjects of which he cannot be a master. Such subjects include meteorology, geology, pedology and others.

Möbius clearly emphasized the *living* community, under the term biocoenosis, as 'a community where the sum of species and individuals mutually limited and selected under the average external conditions of life have, by means of transmission, continued in possession of a certain definite territory' [4] and also 'if, at any time, one of the external conditions of life should deviate for a long time from its ordinary mean the entire biocenose or community would be transformed. It would also be transformed if the number of individuals of a particular species increased or diminished through the instrumentality of man, or if one species entirely disappeared from, or a new species entered into, the community' [5]. Any ecological problem, therefore, must be regarded as an investigation into the activities of living things modifying and being modified by a variable complex of environmental factors, and implies an unremitting search for causes and an attempt to integrate all the facts obtainable.

In that branch of ecology which is known as plant ecology the inter-relationship and interdependence of the living things, the integration of which makes up the living units, has been recognized in the terms applied to communities of vegetation. For example, Clements uses the term 'biome' and 'complex organism' to express the idea that the unit of vegetation is born, grows to adolescence, matures and finally dies even as a living organism does.

I. Theoretical Concepts.

(a) *Classification of vegetation.*

In this enormous country, extending horizontally 2,000 miles from north to south and, including Burma, 2,500 miles from east to west, and vertically from seashore to 29,000 ft. above sea-level, the conditions for plant life are more diverse in India than in any other area of comparable size in the whole world. What contrast could be greater than the humid tropical conditions of Assam and Burma and the arid hot climate of the Punjab plains, or the alpine snows of the Himalaya when compared with the torrid heat of Central India? The contact of man with the vegetation varies from the untrodden and untouched forests of the Eastern Himalaya to the densely populated tracts in which the vegetation is totally annihilated. In between these two extremes are to be found every conceivable degree of interference with the vegetation by man and his domestic animals.

The soils, too, upon which the vegetation is found vary from the igneous rocks of the Himalaya and Southern India to the vast deposits of alluvium of the Gangetic plain. Even the latter shows all gradations from the finest clays to the coarsest gravels and boulder deposits.

It is part of the scientist's nature to classify and tabulate his material in order to be able to erect a framework into which the facts as found in nature can be fitted on a sure and systematic basis. It will be readily recognized, however, that to classify vegetation in India is by no means an easy matter.

In the first place there are very large areas about which very little is known. In the second place the range of soils and climates is great, and soils particularly are little known and understood.

How then is the vegetation to be classified? Is there any system of classification of vegetation on a world-wide basis which can wholly satisfy that objectivity which must be the aim of all scientific investigation? To the latter question a negative answer must be given owing to the fact that our knowledge of the vegetation of vast tracts of the earth is entirely inadequate to enable a relatively final system to be drawn up by general agreement.

Warming [6] based his classification upon the water-content of the soil, one of the most potent factors of plant distribution known. Schimper [7], although he himself says his classification is founded upon a physiological basis, divides vegetation into forest, grassland and desert, thereby giving it a distinctly physiognomic aspect. Graebner classified vegetation on the basis of the amount of soil nutrients present, a laborious procedure which does not carry us very far. Raunkiaer [8] made life-form the basis of a phytogeographical system, taking as the criterion of his classification the position of the perennating buds in regard to the soil. The amount of protection required by the perennating buds against the fluctuation of temperature shows a certain correlation to climate, though it does not necessarily follow that all the species in a given climate will belong to the same life-form. The classification based on life-form, while useful enough to catalogue communities, has been abandoned because of the very nature of plants. It may be that some plants may assume a particular life-form in response to a set of environmental factors but it does not mean that all plants surrounded by the same environmental factors will assume the same life-form, and it is a matter of common observation that different life-forms exist almost everywhere side by side. The frequencies of the various life-forms, expressed as percentages, are called the 'biologic spectrum' of the region in question.

The classification based upon habitat and edaphic factors does not carry us much further. In the first place there is the difficulty of visualizing and of investigating the complex of variable factors which makes up the habitat. Any idea of the uniformity of conditions within the habitat can be abandoned, for the fact is that the actual conditions vary even for the individual species. All these attributes of the habitat or of individual plants or groups of plants having proved inadequate one is forced to take the vegetation itself as the basis of classification.

The latest systems are based on (*a*) floristic similarity, (*b*) physiognomic-ecological characteristics, and (*c*) the conception of succession leading to a climax determined by climate.

(*a*) Braun-Blanquet [9] is the advocate of the system of grouping plant communities according to similarity in floristic composition, taking as a basis the fact that every plant, indeed every race, has a definite greater or less indicator value. Floristically related units are combined into higher units on floristic characters and, therefore, *ipso facto* on ecologic and historic grounds. A close parallel is drawn between the classification and systematic botany, in which species are grouped to genera, genera to families, families to orders and so on. Associations are grouped to alliances, alliances to orders, orders to classes and so forth. The association is the fundamental unit and is said to be strictly circumscribed in space. This system takes no cognizance of status. As far as this country is concerned, the climatic climax type of *Shorea robusta* would be grouped with other *Shorea robusta* forests which are definitely seral in status.

(*b*) Rübel [10] may be taken as typical of those who classify vegetation on the basis of general physiognomy. This classification, again, may be useful as a kind of index filing system in which types of vegetation which have similar morphological characters may be docketed, but it tells us nothing of the relations between the various groups. It will hardly be disputed by anyone that the distribution of the larger ecological units of the earth is closely connected with and dependent upon climatic factors and that these units are characterized by the dominance of plant forms of distinct physiognomy. This system of classification is the static one, and there are signs that some, at least, of the protagonists of the theory find it inadequate.

(*c*) The taking of succession and development as a basis is the dynamic view-point of Clements, the distinguished American ecologist, who has set forth his views in that monumental work 'Plant Succession and Indicators' [11]. Briefly stated, Clements compares a unit of vegetation to a living organism which he calls the 'complex organism' or 'biome' in order to express the idea that the unit of vegetation is born, grows to adolescence, matures and finally dies even as a living organism does.

Now while there can be great similarity in the abstract sense between the units of vegetation and the living organism, this does not mean that the parallel is exact. It is, however, generally recognized that a unit of vegetation is not a chance collection or assemblage of plants which have, somehow or other, arrived at a certain place and have succeeded in establishing themselves upon it, for the very reason that such collections or assemblages occur over and over again in climates and upon soils, which, within limits, are the same. This fact leads to the belief that units of vegetation are organic entities.

It must be emphasized here that the concept of the complex organism, as applied to vegetation, implies not only the plants which form the vegetation but all the other living things which are an integral part of it. This intimate integration of plants and animals is the biotic community or complex organism of Clements.

Tansley [12], the leader of the British school, takes strong exception to the term 'complex organism' or biotic community, on linguistic grounds. He argues that a community implies members and to lump together plants and animals as 'members' is to put on an equal footing things which from their very nature are too different. Similarly with regard to 'organism': plants and animals, considered together, have some of the qualities of organisms but are too different from these to receive the same unqualified appellation. He has not the same objection to the term 'biome'. Tansley would take into his 'eco-system' not only the complex of vegetation and animals but also the environmental factors in the widest sense.

The concept, however, that the community is an organism, while perhaps a useful adjunct, is not essential to the conception of the biome as expressing a living dynamic eco-system of living organisms dependent in its climax stages not upon the habitat but upon the climate.

The dynamic conception of vegetation as formulated by Clements and expounded by Phillips [13] has proved itself to be a powerful tool in the hands of all those who have to deal with vegetation in any of its many forms. The dynamic point of view is particularly useful when dealing with problems concerning vegetation which has not become stabilized. In fact, considered as an instrument for the control of the entire range of human uses of vegetation, the conception of succession is unrivalled.

A logical approach to the dynamics of development will be a consideration of the concept of succession.

(*b*) *Succession.*

This concept is based upon the universality of change, a principle which Warming in 1895 recognized as being inherent in vegetation, but which has only been generally accepted in the last forty years. It is somewhat strange that what now seems to be so obvious should have received such little attention from the earlier and, up till quite recently, the modern continental ecologists.

From within our own experience all of us can give examples of change occurring in vegetation: the bare sand-bank covered with vegetation; the deserted homestead resumed by jungle; the forest replaced by grass; the grassland reduced to bare soil. These are common examples and one would have thought there would be agreement among ecologists regarding their treatment of such areas.

This is far from being the case however and there is still much controversy regarding the meaning of the word 'succession' when applied to vegetation, its direction and its causes. The main differences of opinion on the subject seem to be, broadly speaking, that (*a*) succession is due to almost any cause and may be backward or forward or sideways, and (*b*) succession is due to biotic reactions only and is always progressive.

A considerable amount of heat has been engendered by the various authors concerned when putting forward their own views and criticizing the work of others. As Tansley [14] points out a large portion of the controversy depends simply upon the meaning attached to the word 'succession'. Some would use the word to imply sequences of vegetation, no matter what their cause or direction. Tansley submits that the concept of succession involves not merely change, but recognition of a sequence of phases (admittedly continuous from one phase to another) subject to ascertainable laws. Clements' view is that since succession is developmental in nature it must necessarily be progressive and, moreover, since climatic, edaphic, physiographic and biotic causes are not continuative but initiating causes, progression is due to biotic reaction only. '*Succession* *follows on reaction: succession is inherently and inevitably progressive.'* [15]

It is contended by some ecologists, whose views command respect, that the latter view of succession involves the interpretation of the word 'succession' in a special way which is unnatural. They say that if there is degradation of vegetation due to a continuative cause (burning, grazing, drainage, etc.) then this phenomenon should properly be called retrogressive succession.

Now, it will be observed in this thesis that gradual change due to these biotic (allogenic) factors is accepted as retrogessive succession but that catastrophic changes are excluded. But surely this is only a question of degree. Goats, if numerous enough, can reduce a climax to a bare area overnight. In drier years than usual a fire originated by man can destroy a climax forest in a day. It may be catastrophic but it is merely a question of telescoping the changes which in ordinary circumstances are spread over years.

Anyone in India who has wandered through square miles of forest, untouched and untrodden by man or his domestic animals, cannot but look upon man as something apart from and inimical to vegetation. One can well imagine the opposite view being acceptable to one who has studied vegetation in Europe where almost the last vestiges of the climax vegetation have disappeared before the all-conquering spread of mankind. To such an individual activities of man, such as burning, grazing, hacking, draining, clearfelling, etc. etc., are natural events occurring in vegetation and must be accepted as such.

The acceptance or rejection of the one or the other theory is naturally a matter for each individual ecologist. Little harm is done provided all of us recognize that seral vegetation will inevitably progress provided allogenic factors are excluded.

As far as my own views are concerned, I am convinced that the Clementsian concept of succession is one that deserves the closest attention as being logical and practical and I propose to give a résumé of it.

Before I do that, however, I should like to say something regarding development.

'Succession is developmental in nature and therefore progressive.' These words indicate the intimate relationship of the concepts expressed in the two words—succession and development. The words of Braun-Blanquet, the distinguished Swiss ecologist, have a bearing here 'the principle of development is coming to replace the formal study of succession'. Once the static concept of vegetation is abandoned, the dynamic viewpoint demands the adoption of this view. It is not possible to speak of succession without at the same time considering development. In fact, substituting 'development' for 'succession' in Phillip's phrase above we can say with equal truth 'Development follows on reaction: development is inherently and inevitably progressive'.

We can now proceed to consider succession.

In the first place what is the phenomena of succession due to? Before that question is answered it must be pointed out that succession may be either primary or secondary. That is, the succession can start from scratch, i.e. on a bare area, or it can start at some stage below that of the climax.

In primary succession there are two agencies of succession operative: (1) the initiating causes, and (2) the continuative causes.

Initiating causes of succession.

These causes may be grouped under three heads: (*a*) physiographic, (*b*) climatic, and (*c*) biotic.

(*a*) *Physiographic causes.*—The surface of the earth is being continually changed by certain forces and the result of the processes occasioned by these forces often leads to the appearance of bare areas. Such processes, which have an effect upon the landscape and hence upon the habitat of plants, are (1) erosion, (2) deposit, (3) elevation, (4) subsidence, and (5) flooding.

(1) *Erosion.*—This process, which essentially is the removal of soil through some agency, is quite common in India. The main agent of erosion in this country is water but wind plays by no means an inconsiderable part. The hot wind, known as the *Loo*, which blows during the hot weather in Northern India, is often laden with fine particles of soil which are carried to immense distances. That erosion by wind can reach very dangerous proportions is well known to all of us from the catastrophic sheet erosion due to wind which has been taking place in the United States in recent years. In areas where the natural vegetative cover is maintained intact, erosion is practically negligible. In the hilly regions of Assam where the climax evergreen forest is still to be found, the streams run crystal clear inside the forest even after a downpour of twelve inches in a few hours. It is only where the vegetation has been destroyed that the soil is removed in quantity and even then the amount removed is greatly reduced if some kind, not necessarily the optimum type, of vegetation is maintained. The effects of erosion will be considered later on.

(2) *Deposit.*—This process is complementary to the previous one. If earth is removed at one place it is deposited elsewhere. The deltas of the great rivers are good examples of 'deposit', but everywhere along the course of streams or rivers, especially in alluvial plains, corners are constantly being swept away and sand-banks thrown up elsewhere. In the Himalaya glaciers scoop out quantities of rock which are carried away by the glacial streams. As the ice reaches lower levels it erects terminal

and lateral moraines, that is, bare areas which are open to colonization by alpine plants. Lakes gradually become shallower owing to the deposit of detritus carried into them.

(3, 4) *Elevation and subsidence.*—These two processes are complementary and are not uncommon in the seismic areas of India. During the great earthquake of 1897 in Assam, the bed of the Kulsi river became silted to such an extent that the river flowed into the adjoining sal forest and killed it. Certain parts of the river became land. The elevation and subsidence being comparatively rapid created absolutely bare areas. The slow elevation of the Himalaya does not create bare areas because the very slowness of the process allows the vegetation to keep pace with it.

(5) *Flooding,* too, in India, has been known to create bare areas, especially if the flooding is accompanied by a deposit of silt. Sal forest is sometimes destroyed in this way in Assam and Bengal.

(*b*) *Climatic causes.*—The manifestations which go to make up climate are usually cited here. As a matter of fact, however, unless the climatic changes are exceptionally rapid or the operation of the various agencies very violent, vegetational change keeps pace with climatic change and no bare area results. Avalanches due to heavy falls of snow may sweep through the coniferous forests of the Himalaya, carrying all before them, and a bare area may result. While climatic change may not be responsible for bare areas in India, it is often responsible for a change of vegetation. For example, it is believed in the United Provinces that the climate is becoming drier in western districts, a deduction which is based on the shrinkage of the water-table in wells. This gradual desiccation is leading to the disappearance of the sal tree in the western districts and to the production of a type of forest which is adapted to drier conditions.

(*c*) *Biotic causes.*—Agencies depending upon the activity of living organisms are said to be biotic, and the organism (or organisms), which is responsible for the annihilation of vegetation on an area, is known as a biotic initial cause.*

It will be observed that Man, as a biotic initial cause, has at his disposal means whereby he can simulate some of the agencies which have been dealt with under physiographic causes. For example, the digging of a large canal causes subsidence, elevation and drainage.

The activities of Man and animals can be classified as follows: (1) activities which destroy vegetation without greatly disturbing

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* A distinction must be made between (*a*) *biotic causes,* (*b*) *biotic factors,* and (*c*) *biotic reactions*: (*a*) has been defined above; (*b*) agencies affecting vegetation (not necessarily causing bare areas) which depend upon the activities of living organisms are termed *biotic factors*; (*c*) the mutual effects of the plants and animals forming a natural community are termed *biotic reactions.*

the soil or changing the water content; (2) activities which produce a dry or drier habitat usually with much disturbance of soil (but by no means always); and (3) activities which produce a wet or wetter soil or a water area [16].

With regard to the first of these activities there can be no doubt that man and his domestic animals are extremely destructive of vegetation but they do not act as initiating biotic causes as often as one would imagine. Clearing of forest for cultivation usually destroys the vegetation completely but succession only begins when the field is abandoned. Burning of forest may not be an initiating cause unless it be exceptionally fierce and trees as well as shrubs and herbs are destroyed. Fires of ordinary intensity cause a change in vegetation and do not initiate a primary succession.

The danger of man's activities as a destroyer of vegetation lies not only in the fact that he destroys climax vegetation but also in the subsequent activities which may lead, through the agency of his domestic animals and the initiating causes already mentioned, to the creation of bare areas. For example, in certain parts of India the grazing of immense hordes of cattle on a restricted area eventually results in the disappearance of the vegetation altogether. In the hills continuous grazing causes degradation and eventually erosion on a large scale.

Poisonous gases, such as those given out by brick-kilns, chemical factories, iron-works, sometimes cause the death of the vegetation over large areas, though their usual effect is only to cause a change in the vegetation.

The other activities (2) and (3) refer to the building and excavating activities of man.

Plants in India do not create bare areas. The invasion of areas by *Eupatorium* and *Lantana* and the destruction of plantations by *Loranthus* are not primary succession in that they do not create bare areas.

Insects, too (with the possible exception of locusts), are not initiating biotic causes in India. Elsewhere in the world they have been known to destroy climax vegetation over considerable areas, very often and more usually complementary to some other factor which has created conditions favourable to their increase and spread.

These then are the initiating causes of a sere, i.e. the whole series of changes which result from the colonization of a bare area up to the final stabilized vegetation.

So far I have given a survey of the causes which produce bare areas without which no complete sere can develop. Now it is clear that certain other processes must take place before succession can begin. These are migration, ecesis, aggregation, competition and reaction.

I propose to deal with the first four of these rather briefly and the last-named at greater length.

Migration, ecesis, aggregation, competition.

It is obvious, of course, that succession cannot start unless there be an invasion of plants to the bare area. The process is known as migration and is accomplished in a very large number of ways. Before the succession proceeds any further the seeds, which have migrated, must be able to germinate, grow and reproduce, all of which processes are contained in the term ecesis. There must be large numbers of seeds which are not even able to germinate on a bare area, while others germinate but do not grow. It is certain that only those plants whose seedlings possess the necessary ecological equipment can ecise on any particular bare area.

In the early stages of colonization the habitat has a very definite effect upon the pioneers. Immigrant plants whose demands upon the habitat are too exacting must disappear while those that actually germinate and grow upon the bare area are such as can tolerate the habitat factors actually present. In an area of high rainfall a newly thrown-up bank of sand will act as a very dry habitat even though the water-table be only a few feet away. The first plants, therefore, which colonize such habitats may be xerophytes. If the bare area contains an abundance of water, the resulting primary vegetation will be hydrophytic.

As time goes on, those plants which have succeeded in colonizing the area will set seed, giving rise to other individuals which eventually, as the result of further seeding, come to form a closed community.

When this stage is reached there follows the inevitable competition or struggle for existence in respect of the supply of light, water and nutrients. This competition naturally results in a decrease in the amount at the disposal of each individual of one or more of these commodities. Once this stage is reached the plants begin to have a very definite reaction upon the habitat and upon one another.*

Reaction.

The ways in which plants may react upon the habitat are very various. To mention a few: plants (*a*) build up and stabilize the soil, reduce surface evaporation, (*b*) add humus and thereby improve the water-holding capacity, (*c*) alter the acid value of the soil solution, (*d*) by the mechanical action of their stems can cause the deposit of water-borne particles of soil and therefore help to reduce the depth of water in lakes and ponds, (*e*) alter light conditions at the surface of the soil and enable

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* This does not, of course, exclude the possibility of plants reacting upon the habitat from the very moment of their appearance.

shade-loving plants to appear, and (*f*) influence the appearance of soil micro-organisms, and of course in many other ways.

In closed forest the effects of the vegetation on the soil may be very important. The amount of organic matter returned to the soil every year by the plants themselves varies from 20 to 100 tons per acre. This enormous quantity of material is seized upon at once by an innumerable number of organisms and under tropical conditions rapidly disappears. Humic substances are, however, constantly added to the soil and while the layer of litter may be thin and a humus layer absent, the soil itself is rich in humic and mineral substances. Forest soils are characterized by a strong acid reaction up to a considerable depth and this acidity prevents 'allitic' weathering. Even where the parent rock is strongly basic the soil reaction, although approaching *p*H7, is still faintly acid.

An important point in connection with the growth of plants upon an area is that the plants tend to reduce the water content in very wet places and to increase it if the soil is very dry. This tendency, of course, does not proceed beyond a certain point. It has been mentioned that the conditions of life for the colonizer may require certain adaptations in plant form or construction. As time goes on, however, and as the plants react upon the habitat and upon one another, conditions come into being which are very different from those originally present and which do not call for special adaptation. This explains why the original pioneers gradually disappear. They have created conditions of which other plants can take advantage and this process is repeated until the conditions present are stabilized and there is no more invasion and the vegetation is in harmony with its habitat.

The law enunciated by Liebig * that when a multiplicity of factors is present and only one is near the limits of toleration, this one factor will be the controlling one, applies in this case and it is most important to realize that vegetation which is in a state of succession, i.e. in a seral state, can be invaded by a plant of higher life-form whose minimum requirements are met by the improvement in the habitat brought about by the biotic reactions.

Secondary succession.

So far we have only considered succession as a process continued by the reactions of the plants and animals unhampered by outside influences. This state of affairs is unhappily a rarity

* Taylor, W. P. (*Ecology*, XV, 378) restates the law as follows: 'the growth and functioning of an organism is dependent upon the amount of the essential environmental factor presented to it in minimal quantity during the most critical season of the year, or during the most critical year or years of a climatic cycle'.

and the super-dominant man with his fire, his domestic animals and other methods of destruction is usually actively at work. Let us consider briefly at this stage the effects of fire and grazing animals upon progressing vegetation.

Fire long continued will destroy and prevent the appearance of all species which are not adapted to meet this menace. The species which can withstand fire are comparatively few in number and they are to be found forming a relatively stable community in districts where the danger from fire is high. The most frequently adopted protective devices are (*a*) an underground system which cannot be destroyed by fire together with aerial parts which can be lost without damage, and (*b*) the adoption of a thick corky bark and, in addition, the deciduous habit.

In India, for example, during the dry months of the year the danger from fire is very great. At this period fires go roaring through the grasslands and the deciduous forests. Shortly after the fires are over, the tree species begin to send forth their leafy shoots, the underground parts of the grass send up their tender first leaves and in a month or two there is no sign of the blackened ruin that was left behind after the fires had passed away. Observations long continued have convinced ecologists that a progressing succession is slowed down and eventually halted by fire at a certain stage, and as long as the fire factor is operative, the vegetation remains in this stage.*

Similarly in the case of the village grazing ground it is common knowledge that the village grazing ground changes only within narrow limits. As long as grazing continues the only species which can survive are those which are adapted to withstand such factors as nibbling and trampling. If the number of animals grazed is very large, bare patches appear which may or may not be covered with some species which is distasteful to cattle. If the number of cattle grazed is less, then the pasture grows a little thicker.

In the two cases which have been mentioned the vegetation has been affected by certain extraneous factors or biotic agencies which have influenced it to such an extent that the progression has been halted and maintained in a more or less static condition.

Stabilization.

Vegetation, if left to itself, continues to progress as a result of biotic reaction. As habitat conditions improve, a series of invasions takes place and each invasion occupies the habitat for a time until it creates conditions in the habitat of which some more exacting species can take advantage. A time must come, however, when a state of equilibrium is reached, at which the vegetation and its environment are in complete harmony.

* Unless it is ousted by an exotic.

This stage is controlled by climate, because climate alone determines what the dominants in any climatic region may be and what life-form the dominants of the final vegetation will assume.

(c) *Climax.*

I have explained that, during its development, vegetation has certain reactions upon its habitat which bring about certain changes therein which enable a higher form of vegetation to replace a lower, and also that there must come a final stage in which no further advance is possible under prevailing conditions and the vegetation is in complete harmony with its environment. This final stage is called the climax and is the highest expression of the vegetation for a given climate.

Nobody doubts, nowadays, that climatic factors are responsible for the larger ecological units (of vegetation) of the earth and that these units are characterized by the dominance of plant forms of distinct physiognomy. Both the dynamic and physiognomic schools of thought base their classification on the basic effect of climate and, therefore, there is considerable agreement in their delimitation of the major communities.

There is, however, a wide divergence of opinion as to the exact meaning of the word climax. For example, what status are we to assign to the following relatively stable communities: (1) a grassland which is burnt every year, (2) a community of *Cupressus torulosa* upon limestone, and (3) the vegetation of a mangrove swamp?

All these examples are certainly relatively stable, in fact so stable that during the lifetime of several men there may be no change. On the other hand, nobody doubts that, if the annual burning is discontinued for a long time, the grassland will disappear and be replaced by forest. As far as the *Cupressus* forest is concerned, experience in the Eastern Himalaya indicates that it may eventually be replaced by oak and pine. Neither is the mangrove community really stable. A great deal of what is now fertile cultivation close to the seashore near an estuary must have been at one time under mangroves. It is not certain, of course, that the mangrove will change to something else because the community may be swept away in a catastrophe. If, however, land formation proceeds by deposit as in many estuaries, the mangrove belt is pushed further and further out to sea. Cowan [17] has instanced the reverse process in his account of the vegetation of the Chakaria Sunderbans where he states that, owing to a violent tidal wave in 1897, doubtless connected with the devastating earthquake of that year in Assam, a great deal of cultivated land was inundated and was resumed by a growth of mangroves.

The instances quoted above are examples of communities of vegetation which are relatively stable, but which are not controlled by climate alone but in addition, in the first case, by the biotic factor fire; in the other two by a soil factor. The former is considered by some to be a true climax and is called a biotic climax and the other two are called edaphic climaxes.

Now, it is obvious that these two concepts are of very different status. The biotic climax is a stabilized type of vegetation which owes its stability to a factor which can be discontinued at any time by man. In the other case the edaphic factor is not as a rule one which man can alter, and must be altered by the reaction of the plants themselves on the habitat if there is to be progress towards the normal climax. Man can, of course, in certain cases, such as draining a swamp, cause an edaphic factor to disappear.

Clements accepts only one climax and those other communities of stabilized vegetation he considers are proclimaxes, disclimaxes, etc., asserting that, once the disturbing factor is removed, advance begins at once. Phillips [18] introduces easily understood terms to indicate that the progress of succession is deflected, retarded, accelerated or stopped in a certain stage. The change of vegetation due to a soil impoverished by a leaching out of nutrients still remain a problem.

Other workers, for example Bourne [19], vigorously criticize the protagonists of the monoclimax theory. Bourne lays great stress upon the soil in the control of the climax type and goes so far as to say that there may be many edaphic climates within an area in which the climatic factors are the same. He says 'the real tests of a climax are stability of topography and maturity of soil profile in relation to climate, as well as the presence of climax dominance'. Quite recently it has been pointed out that in lowland tropical regions, tropical red earths and well-marked podsols may develop side by side, following differences in the parent rock, in the same climate, and that these two soil types bear distinct climax vegetation types. If such be really the case, its importance as a support for the polyclimax theory cannot be minimized.

In regard to the stress placed upon maturity of the soil and its influence upon the climax it is well to remember that most of the present forest climax units of India are in the hills, where the soils are often shallow and extremely stony. In fact it is common in the sholas of the Nilgiris, the forests of the Western Ghats and those of the Himalaya to find that the underlying rock crops out here and there. It may be pointed out here that in tropical forest, especially in rain forest, the forest lives largely upon the products of its own decay. This type of forest is remarkable for the luxuriance of its vegetation. The large amount of litter which is laid down on the forest floor every year is rapidly decomposed and its mineral constituents made available for the growth of the trees. Now if the forest lives largely upon the products of its own decay it is obvious that a luxuriant forest does not necessarily indicate an extremely fertile soil. A luxuriant forest, if such be the climax type for a given climate, will develop as surely on a poor soil as upon a fertile one. It may take a much longer time but the final result is the same. This is a point to remember when false arguments are put forward to boost up a demand for throwing open forest to agriculture. As has been indicated elsewhere in this address, climax-forest-soil accumulates, during its centuries of intimate relationship with the vegetation, stores of humic substances, which, should the area be thrown open to cultivation, may give an entirely wrong impression, in the first few years, of great fertility of soil. Bumper crops can be taken off forest soil, but as exposure rapidly reduces the stores of plant remains, these crops dwindle, and unless the soil be naturally fertile, as too rarely happens, become mediocre or even bad. This experience often leads to further agitation for more forest land and, naturally, to a vicious circle.

Bourne instances the case of the fired area and states that there are many climates which would support an evergreen vegetation were it not for forest fires and their effect upon the soil. He points out, however, that where laterization has followed the retreat of the evergreen the return of all but a few of the more tolerant evergreen species is often prevented. Until laterite is eroded and more mesophytic soil conditions are developed the original vegetation cannot reinvade the area. The formation of laterite is not, however, dependent upon any influence exerted by the vegetation.

An important paper by P. W. Davis, I.F.S. (*Indian Forester*, LXVI, 658) is of interest in this connection. He points out that the now established technique of raising teak plantations ensures success in the first year, but experience in Malabar has shown that, in some cases at least, subsequent development is not at all uniform and a proportion of the area planted out shows a falling off in height growth and increment. In certain of these areas soil pits were dug and the soil profiles were examined and found to show an advanced stage of laterization. The author goes on to discuss the theory of laterite formation which is taken to be due to (*a*) a leaching process, (*b*) a silicate decomposition process, and (*c*) a sesquioxide accumulation process. The first process, that of leaching, takes place in the wet season. Owing to the high temperature prevalent in areas where laterite formation goes on, there is also a vigorous decomposition of the original alumino-silicates so that the silicic acid is leached out leaving an insoluble residue which is for the most part a hydrate of aluminium oxide. This chemical action proceeds to considerable depths so that in perpetually moist zones we find a purely allitic layer above the parent rock, which, while it retains somewhat the structure of the original rock, contains principally sesquioxides unaccompanied by silicic acid.

This substance is called primary or high level laterite. In areas, however, which are not perpetually moist, but in which a wet and dry season alternate, the surface evaporation causes an upward migration of a solution rich in sesquioxides. This causes an accumulation zone near the surface which is rich in Fe_2O_3. Now, provided the original forest is kept intact, this upward or downward trend of solution rich in sesquioxides has no effect upon the vegetation or the soil since the humus present in the surface layer acts as a protective colloid and keeps the sesquioxides in solution. Moreover, the temperature and humidity in closed forest are not likely to vary within the wide limits which are usual outside forest. If, however, the humus layer be absent and the soil exposed to the extremes of heat and varying degrees of humidity, then a layer of laterite forms upon which it is not possible to induce the species of the original forest to grow.

From this example emerges the fact that if a climax forest in the tropics is destroyed by man, it is quite possible that soil changes may make the return of the climax impossible. An investigator will find the vegetation occupying a lateritic soil quite different from that of the neighbouring forest and apparently static and there will be nothing to show him that the vegetation is actually seral and not climax.

The question of the laterization of the soil—due to exposure following the effects of fire long continued, which has removed the evergreen forest; or upon the more rapid destruction caused by man in his efforts to create a more valuable tree crop—raises another question akin to it. This is the question of the status of the hill grasslands which are such a marked feature of the hills of India, Burma and Ceylon.

The hill grasslands of Ceylon are considered in a long paper by Pearson [20]. These grasslands, called *patanas*, have been in existence for a very long time and as they are situated in an area of high rainfall their stability has given rise to some speculation. I cannot, from a search through the literature, find out whether any work has been done on these patanas since Pearson's work in 1897. Pearson believed that the patanas arose from the effects of long-continued grass fires and that, owing to the heavy rainfall, the soil of the area below 4,500 ft. has been swept away and therefore the reafforestation of the greater part of this area is impossible under the present climatic conditions. With regard to the area above 4,500 ft., it appears that an accumulation of sour humus prevents the ecesis of forest tree seedlings. Both areas Pearson considers to be stationary and permanent although he agrees that their origin is directly due to the destruction of the forest. As Pearson does not differentiate between seral and climax vegetation in his paper one cannot be sure what are the intermediate stages between grassland and forest, but it is clear that, notwithstanding the fact that the author considers these patanas to be climax, they are really only a case of succession-termination.

The grasslands of the Nilgiris, Khasi Hills, Naga Hills, etc. are also very extensive and they are also extremely stable. The climate is the so-called forest climate and although evergreen forest is present in folds of the terrain, it does not seem to be able to advance upon the grassland. The factors with which the forest has to contend are fire and grazing, two factors which world-wide experience has shown to be capable of reducing forest to grassland and of keeping it in that state for a long time. This is sufficient to explain why forest does not advance on grassland, but even if the species of the forest are taken and planted or sown in the grassland and the latter protected from fire, it is found that they do not survive. If unprotected from frost they die, if protected they do not grow.

These grassland areas are typical biotic climaxes which have existed for a very long time. When a biotic climax of this nature is maintained in its subordinate state the loss of soil by erosion must be very considerable, especially if fire is a factor, and much greater than it would be if the area were covered with forest. Changes, similar or related to laterization due to exposure and continued burning, may also take place and make the soil unsuitable for the climax species.

There are, however, very good grounds for believing that, no matter how stable the grasslands may be, they are really only seral in status. When one considers the life of the seedlings of the evergreen forests, i.e. the individuals which will eventually replace the dominants, one realizes that their early life is spent in an environment which is the very antithesis of that which suits the mature tree. The mature tree endures insolation, frost and all the vagaries of the climate and flourishes. The seedling, on the other hand, is protected from early youth upwards from all these extremes, and even its light requirements are usually very different in the early stages of its existence. It grows upon a soil which has been the subject of reaction possibly for centuries or even thousands of years. It can be no cause for surprise that such seedlings fail to survive in the rigours of the grassland. In fact if one accepts the theory of succession—that succession is due to reactions only and is progressive—one can only come to the conclusion that it would be impossible to replace the grassland by a plantation of the evergreen species. The stages of the sere from grassland to evergreen may be telescoped by artificial means, and short cuts may be taken within limits; but to replace a stabilized biotic type by the climatic climax is a task apt to be attended by some difficulty. If, on the other hand, some of the earlier and woodier stages of the sere are reproduced and inimical biotic factors kept at bay, there is no reason to believe that a gradual return to the climax would not be possible.

Another type of climax which has been described by certain workers is the fire-climax. This is a type of relatively stable vegetation which has arisen as a result of fire. It is similar in status to the biotic grassland climax which is the result of, and is maintained in a stable state by, fire. The name, however, in India at least, is usually applied to the well-known sal (*Shorea robusta*) forest which, were it not for the fire factor, would, at least in Eastern India, change into evergreen forest. As the last few words of the previous sentence imply, this type is considered to be a case of succession-interruption or -termination.

From the foregoing it will be clear that if one accepts the polyclimax theory it would be possible to have several well-marked stages, all of which could be called a climax, qualified by some word such as 'fire' or 'biotic' or 'edaphic', on the way to the true climax, i.e. the climatic climax. Incidentally, as long as one recognizes that all these states are only transitory there is need for only one term to express the highest type of vegetation capable of maintaining itself in a given climate: *the climax*.

To assume that the climax is of uniform structure throughout would be erroneous, because the climax, being a living unit, a biome, organic entity, complex organism or whatever name is applied, is subject to minor fluctuations in the climate and will adjust itself to these fluctuations. Here and there will be found areas in which the rainfall is a little heavier or a little less than the normal, here the soil better drained and there more water logged. All these local differences call forth a response from the biome and small differences will be found in the composition of the vegetation.

Before passing on to the next portion of my address I should like to recapitulate certain principles which I consider fundamental for the study and solution of ecological problems in India. First of all with regard to succession. This phenomenon is progressive and is due to biotic reactions only. This excludes any concept of retrogression due to biotic factors such as grazing, fire, draining, flooding, etc. In order to maintain intact the developmental theory of vegetation it is better to consider separately all extrinsic factors of this nature. Biotic (allogenic) factors certainly do affect the succession in various ways. These effects can be described according to the rate and direction of the results with such terms as succession-acceleration, -retardation, -deflection, -interruption, and -termination [21]. In view of the fact that biotic factors—factors for the most part over which Man has control—have such a tremendous influence on the succession, it is clear that if we only know the stages of the sere it is possible to influence and mould its course and speed in order to suit our own purpose.

Coming to the climax, we have seen that the climax is 'the final stage of biotic development in the climatic unit'. The climax is a product of and is controlled by a given climate. Vegetation which has not reached the climax stage is unstable and is irresistibly urged along the path towards the climax. A forest climate sees the victory of the forest if the sere is left to itself. A desert climate, on the other hand, sustains a desert vegetation and so on. 'As the final stage of a sere, the climax is less flexible in terms of manipulation, but it is capable of similar control; it can be protected and held against all but climatic change as in research and wilderness areas. It can be enriched or impoverished, and it can be destroyed in such a way as to reproduce itself or so completely as to render this impossible, thus permitting a wide range of substitutions within the limits of climate and soil.' [22]

II. The Study of Ecology in India.

In this country the study of ecology has not made the same notable strides as other biological sciences have and it is worth while pausing for a moment to consider possible reasons for this apparent lack of interest in the subject.

For some reason ecology is not a popular study. I know of only one case—there may be others, for I am not in touch with academic circles—in which a student submitted a thesis on an ecological subject for his M.Sc. At one time the pages of the *Journal of the Indian Botanical Society* contained articles on this subject: it is a rarity, nowadays, for an article on ecology to be published in that paper. How has that come about and what is the reason for it?

One possible reason is that ecology is a new science and is one that cannot be relegated wholly to any of the firmly established and circumscribed branches of knowledge like chemistry, physics, botany and the like, but demands the co-operation of a number of such sciences. The borderlands of science, of which ecology is one, have always had, in their beginnings, little attraction for students and this is a fact which has been recognized for some time, at least in American scientific circles. The importance of research in the borderlands of science is fully realized in America and steps have been taken to see that such research is not left wholly to chance. As Bowman [23] remarks 'the greatest borderland of all is that between the physical and natural sciences on the one hand and the social sciences on the other. It seems probable that the cultivation of this borderland will be the distinctive mark of the next epoch of advancement of organized research'.

It may be that in India we have that superficial and arbitrary division of biology into 'pure' and 'applied', which has been exercising the minds of educationalists in Europe for the past twenty years and more. Attention has recently been called to this state of affairs in England owing to the embarrassingly small use made of pure biologists in times of war. The tendency of biologists to become narrow specialists in one or another branch of pure biology is much deplored and serious steps have been taken to bridge the gap between the 'pure' and the 'applied'. These efforts, in England, have had the opposite effect to that desired and have driven the specialist to take refuge in his specialization where he is remote from the practical application of his science to the affairs of everyday life.

In England we find the academic posts in the hands of the specialists while the applied posts are occupied by those who have been trained by the specialists but who have broken away from tradition. The danger lies not in the fact that there are specialists in pure biology but in the fact that there is no intimate contact between pure and applied research: hence the danger of isolation of the specialist. 'What all biologists would deplore is that pure biology, defending its virginity, should lapse into barren spinsterhood.' [24]

Another possible reason which has discouraged young scientists from studying the subject is the impossible and ridiculous nomenclature which some writers consider necessary for the exposition of their work. Words such as aerodomatia, angonekton, blastochore, driodad, endoxylophyte, isodem, hemicryptophytosynusium, promunturium, stegonachamaephytium, etc. are quite unnecessary and are better relegated to the dust-bin of discarded monstrosities.

There is no real necessity for such terms and I hope all writers in India will resist the temptation to coin new words to describe concepts which are new or fancied to be new.

A certain amount of descriptive ecology * (plant sociology or synecology) has been done by a number of workers in India. Studies in the autecology of the individual plant have also been carried out. All these are to the good, and a further step in the right direction has been made by the recent creation of a scientific society, the Indian Ecological Society, which will have as its special care the fostering of ecological study in India.

The work that lies before us is immense. Not only have we to catalogue and describe the seral and climax units of this great country with all its varieties of soils and climates,

* The most important of these is 'A Preliminary Survey of the Forest Types of India and Burma' by H. G. Champion, which was published as an Indian Forest Record, Silviculture, Vol. I, in 1937. Champion refers, in his bibliography, to nearly all ecological work done in India.

we have also to take up and deal with the problems arising from the daily contact of Man and his domestic animals with vegetation.

Let me indicate briefly some of the ways in which problems relating to vegetation, its maintenance and management, arise and are dealt with in India to-day.

III. Practical application of Ecological Concepts.

(a) *Shifting cultivation.*

For long periods in the history of the earth before Man appeared the land must have been covered with vegetation of some kind which was in harmony with the climate of that distant age. The floristic of those climaxes is different from that of the climaxes of to-day, but when man first made contact with the vegetation the genera and species must have been very much the same as we know them to-day.

It can safely be assumed also that successional phenomena were much less common than they are to-day and bare areas only occurred where water made contact with land, on high hills where slips occurred and on areas where catastrophic devastation of vegetation took place through the forces of nature.

The advent of Man upon the scene meant, from small beginnings, the eventual destruction of climax vegetation over almost the whole of the surface of the earth.

As Man learned the use of fire and the benefits of cultivation, the climax forests were attacked and from that day to this the dogma that 'Man destroys to plant and plants to destroy' has been very nearly a truism. It is generally agreed that at the present time there is only a minute area of vegetation which is not subject to the interference of Man and his domestic animals.

In most European countries the primeval climax has long since disappeared and the last strongholds may even now have fallen a victim to the ruthless Nazi exploitation of other nation's property. In this country little of the untouched climax forest remains, but in the Eastern Himalaya are still to be found areas which for one reason or another have escaped the woodman's axe or the cultivator's hoe.

The effect of Man's contact upon vegetation is a tale of destruction in almost every case, varying from the slightest effect to complete annihilation.

Of all practices initiated by Man the most noxious is that of shifting cultivation. In this type of cultivation the forest is felled and burned and a crop is raised in the ashes. It is well to consider what this practice means. The first time the forest was felled it was most likely climax forest, that is, the culmination of a sere which had probably lasted many hundreds of years. Vageler [25] estimates that the production of fresh organic matter in primeval tropical forests approaches on a conservative estimate

100 tons per acre per year. He points out that in temperate climates this quantity would result in a layer of humus many yards thick. That such accumulations are not found in tropical forest is due to the innumerable organisms, plant and animal, which are occupied with the destruction of the residues of the higher plants. In fact the destruction of organic matter proceeds so quickly that it is a rarity to find one-eighth of an inch of humus and the thickness of the litter is also negligible. As Vageler says 'the yard-deep humus layers of the tropical forest are poetic fantasy'. The soil is, however, rich in humic substances to a depth of several yards and this explains its great fertility. Exposure to the sun and air, coupled with crop raising, rapidly reduces the fertility produced by centuries of biological reaction. After a second crop is taken off the soil, deterioration sets in rapidly and few *jhums* * are cultivated for more than two years.

Erosion during the period of cultivation, especially on steep hillsides, is very great and large quantities of soil are removed during the rains in districts where this practice is still allowed. In the Naga Hills, Assam, cases are on record in which so much soil had been removed from cultivated fields by the agents of erosion that the bare rock was exposed. The only resort left to the cultivator was to carry up soil from the river-bank several thousand feet below and pour it out on the bare rock in order to make a field.

Now when the area is abandoned the odds are heavily against the species of the original climax forest appearing. If you have followed the argument regarding development you will understand that the conditions necessary for the immigration and ecesis of these species are absent.

Climax and succession being what they are, it follows that once the disturbing cause ceases, development is immediately resumed. If the field is left to itself, it begins, after abandonment, its slow but inevitable march to the climax. But, be it remembered, that march is by stages. We do not at once get back the climax. That state is only reached after the migration, ecesis, competition, coaction and reaction of the plants and animals that make up the various stages in the sere.

It follows, therefore, that the vegetation which takes possession of the abandoned field will be something lower in this stage of development. Very often it is only *Eupatorium odoratum*, a South American weed, or grass, or even softwooded trees. As far as is known at present the succeeding woody species are almost always those which make little demands upon habitat. They are often rapid growers and possess seeds which are either very light or possess special adaptations for wide dispersal.

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* This word is applied to shifting cultivation in the hills of Assam.

Communities of vegetation, such as these, are usually loosely called 'secondary' and, if protected from fire, slowly change to something which more nearly resembles the climax which it has replaced. On the other hand, if fire be a danger there is little or no progression but the woody species which come in the first instance may even disappear.

As matters stand, however, such areas are not allowed to progress very far because increasing population compels the villager to cultivate his field at shorter and shorter intervals. Should the interval between two periods of cultivation be too short the land deteriorates rapidly.

This process of the destruction of evergreen forest by the hill cultivator and its replacement by something less valuable and less highly organized is quite common in the Himalaya and the hills of Eastern and Southern India.

The reduction of tree-covered hillside to grassy slopes has assumed alarming proportions in recent years in the North Cachar and Naga Hills. It is well known that forest is very effective in holding up rain supplies while grassland, although more efficient than bare soil, allows a proportion of the rain-water to flow along the surface. In Assam, where rainfall is apt to be exceedingly heavy, the danger from erosion is great and, moreover, the rapid descent of large volumes of rain-water into the valleys is likely to cause flooding. The extremely humid atmosphere of Eastern India, however, ensures that any bare space is covered with vegetation in a very short space of time and badly eroded areas are not common.

The plains and foothills of North-West India stand in complete contrast. Here the climate is very different from that in the east and is characterized by great extremes of temperature and a rainfall of less than 40 inches. In these areas there is not that exuberance of vegetation which a generous rainfall and a more uniform temperature call into being. The soil carries a poor scrub forest of thorny trees. Where preserved this forest can maintain itself and the trees grow close together and the soil is protected by a more or less complete grass cover. Where, however, cultivation and grazing, especially by goats, is allowed to proceed unchecked the vegetational cover is removed and the unconsolidated alluvial soil of these parts is eroded to an alarming degree. The problem of the prevention of erosion and reclamation of these lands is one of the greatest the Forest Department in the Punjab has ever faced.

What I have just described is a grave misuse of land which is tolerated in certain tropical countries at the present day but which, it is safe to say, will not be permitted for an instant once it is generally realized how dangerous it is to allow a certain class of people to do as they like with the vegetative covering of the area they occupy.

This dictum may seem to be the negation of democratic principles but it is now beginning to be realized in this country that what is done in the hilly areas of one province may have dire effects in the plains districts of another province.

An improvement on the method of the shifting cultivator is the maintenance of permanent fields. In the hilly areas these fields are terraced and water is ingeniously distributed over a whole hillside, whereby little soil is lost. Unless, however, fields are properly laid out along the contours, erosion is often very heavy. In Lahul, for instance, enormous quantities of soil are removed owing to the reckless way water is led into a field for irrigation purposes.

The question of the permanent field in the hills leads one to the problem of supplying those fields with the necessary water for irrigation. It often happens in hill districts, where *jhuming* * has been allowed to proceed unchecked, that when the time comes to turn over to permanent fields, a water supply is difficult to obtain. This is almost invariably due to the absence of vegetation on the hill slopes.

It is a pity that what seems so obvious and clear to us to-day should not have been so to the administrators of the past. The almost insoluble problems which arise at the present time in the hills, where an increasing population is faced with a limited area of land of diminishing fertility, would never have arisen had the implications of uncontrolled jhuming been understood.

(*b*) *Forestry.*

We have seen that Man's contact with vegetation, so far, has been a sorry tale of destruction. To turn for a moment to the management of our forests shows Man in the rôle of protector and in a more favourable light.

'Forest vegetation is composed of plant communities or units of vegetation, developed and arranged in accordance with definite biological laws and is not an aggregation of trees and other plants brought together by chance.' [26]

No matter how one may marvel at the climax forest as a living entity, with all its myriads of different forms of life, each acting upon and being influenced in its turn by the other living members of the community, it does not always conform to what present-day Man considers to be an ideal forest.

For example, the luxuriant evergreen forests of the Western Ghats or the Eastern Himalaya conjure up visions of the 'inexhaustible forest wealth of India'. The trees are there in enormous numbers but the number of valuable trees per acre is so few that it really does not pay to work the forest. For example, in the forests of the Western Ghats, the number of different

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* This term is applied to shifting cultivation in Assam.

species may be as high as 160, but trees which are considered valuable are not more than 2 per acre.

In areas where the stock is richer the forests are of course exploited, but the very fact that they are exploited introduces an extraneous biotic factor which has an effect upon the vegetation.

Now it is quite clear that Man can affect the climax in various ways though it responds much less rapidly to his manipulation than do the stages of a sere. It can, however, be enriched by the encouragement of the more important species, or it may be impoverished by cutting out all the valuable species without caring very much what follows them. It can be destroyed and replaced by plantations of the more valuable species or it can be destroyed so completely as to render its reappearance impossible.

The principle of the conservation of water supplies by the retention of the vegetative cover of the soil is well understood by forest officers who plan the working of their forests so as to maintain an unbroken cover as far as possible and at the same time exploit their forests so as to give a legitimate sustained yield of timber.

The fine work of the Forest Department in the last century was largely the result of the application of continental principles of forestry to the forests of India. On the whole this has worked well and an immense amount of empirical information was stored up as the decades passed.

The continental methods were applied with more or less success to the temperate forests but with decidedly less success in the tropical plains forests. In fact the application of European methods of conservation actually did harm in some cases.

A brief example of this must suffice. In accordance with the practice in vogue in the German and French forests, where officers of the Indian Forest Service received their training, a policy of fire protection was extended to the forests of India. This of course benefited ecologically those forests which exhibited succession-termination owing to the effects of the long-continued fire factor. According to the principles enunciated above when the fire factor was removed such forests would at once continue the succession towards the climax type. This is exactly what did happen to the great embarrassment of certain provinces in which the fire sub-climax forest (*Shorea robusta*) was far more valuable than the evergreen forest which was the natural climax. In these forests the light grassy undergrowth, which was common when the forest was burned, turned into an impenetrable growth of evergreens, in many cases so thick that it needed many years of forced burning to reproduce the grass. In such an undergrowth the appearance and development of sal seedlings is impossible. In these forests the aim at the present time is to prevent the succession from proceeding too far and to prevent this from happening firing or shrub cutting are prescriptions in the various working plans. In other words, the object of the management is, by the imposition of a biotic factor or factors upon the unstable vegetation, to cause succession-termination and to maintain the forest in that state.

Forest officers have been forced more and more to consider the subsidiary species in their forests. From being regarded as a nuisance many of these species are now known to be very important in the biological relations of the living trees. Many are food plants of insect parasites of the insect pests which damage the valuable trees.

A great deal of valuable empirical knowledge has accumulated at the expense of much time, labour and cash, which could have been appreciably diminished had the problem been approached from the ecological angle. The technique of raising plantations of valuable evergreen species has been so improved in recent years that nowadays failures do not exist. In the past attempts to raise plantations of valuable evergreens, without any regard whatever for the ecological needs of the species, almost invariably ended in failure.

The raising of pure plantations of species which do not occur pure in nature, and their subsequent extinction or devastation through the attacks of insects and plant parasites, has drawn attention to the fact that Man, superdominant though he may be, cannot afford to upset too outrageously the reciprocal relations which exist between all forms of living organisms in an area without eventually having to pay the penalty.

The planting of the tree *Gmelina arborea* is a case in point. This tree is not found growing in pure stands in India, but owing to the value of its timber as a furniture wood, and the ease and rapidity with which it can be established, large plantations have been raised in Bengal, Assam and Burma. In Bengal and Assam, plantations amounting to hundreds of acres have been wiped out by the plant parasite *Scurrula parasitica* Linn. (*Loranthus scurrula* Linn.). In the Northern Shan States over 2,000 acres of plantations of this species with a capital value of Rs.1,50,000 had to be written off in 1936, owing to the depredations of the beetle *Calopepla leayana*. It is impossible to raise pure plantations of *Michelia champaca* Linn., another species not found pure in nature, because of the bug *Urostylis punctigera*.

Dr. Beeson [27], till lately Forest Entomologist at the Forest Research Institute, Dehra Dun, has in his recent book on forest insects stressed the necessity for regarding the forest as a biocoenosis, biome, organic entity or whatever term is used to cover the whole range of living organisms contained within it. He gives many examples of serious losses, through completely unsuspected pests, which have occurred by neglect of, and interference with, the natural laws of forest biology. A deeper acquaintance with these natural laws (i.e. study of ecology) is responsible for the tendency in recent years to get away from the 'artificial' and back to the 'natural' in Indian forestry.

(c) *Grazing.*

Before any ecological problem is tackled it is of the utmost importance to decide the ecological status of the community with which one proposes to deal. Grazing implies grassland of some sort, whether open savannah or grassy stretches dotted over with trees. Everyone is familiar with the vast stretches of grass, whether tall or short, which one sees everywhere in India. The rolling downs of Ootacamund, the grassy hills of the Shillong plateau and other places are familiar to some of us. What status are we to assign to such areas? Are they climatic climaxes or are they seral in nature?

Champion [28] has expressed the opinion that nowhere in India is grassland a climax type. True grassland is developed, according to v. Faber [29], in a climate which is characterized by the following elements: (*a*) frequent precipitation of rain, even if the amount be small, sufficient to keep the upper layers of the soil moist during the vegetative period, and (*b*) sufficient warmth during the growing season. The underground water supply is considered to be relatively unimportant. It would be, perhaps, unwise categorically to state that these conditions do not exist anywhere in India. India possesses such an enormous range of environmental factors that it is possible a grassland climate does exist over a very small area, but it can be stated with complete confidence that in India the climate is either a forest climate or a desert climate for areas of any size.

Hence it is clear that those grassy areas which, for example, are such a conspicuous part of the landscape in some of the wettest parts of India are seral in status.

Stress has been laid elsewhere (Bor [30], 1938, 1941) that the species of grass which are found in grassland in forest climates belong to the more highly developed genera. The reason for this is that their migration to the open country has tended to vest them with adaptations which are not necessary in the habitat which has changed the least, i.e. the tropical forest in which their ancestors presumably arose. Grasses of this kind are usually very fibrous, have a well-developed rhizome, and produce seeds which are adapted to transport by air or by animals. Now while these adaptations enable the grasses to survive the effects of fire and the ordinary browsing of wild animal, they are completely useless before the onslaught of man and his herds of cattle.

The cattle do not like the mature grasses and will only nibble the tender new shoots. To obtain these shoots the herdsman fires the jungle and the rhizome of the burned grass responds by sending up the desired shoots. If the incidence of grazing be high, the rhizome eventually dies or the grass assumes a depauperate form.

Tall grassland, therefore, is usually the result of firing plus the ordinary grazing of wild animals. The short turf grassland is often brought about by burning plus a high incidence of grazing. Grassland in forest is only incidental and would disappear if the trees were grown closely enough. In forest, however, especially in deciduous forest, grass will persist with the aid of fire.

Having ascertained that grassland in India is seral the implications must be stressed. A seral unit is unstable and can be moulded by biotic factors to the desired end. Grassland is always striving towards the climax and if the biotic factors which have caused and maintain the grassland are removed, the succession will proceed by the ordinary stages towards the climax. In most parts of India one of the intermediate stages is some kind of deciduous forest. It has already been indicated that some of these intermediate stages may be more valuable than the end product. It will be realized, therefore, that succession is a most potent weapon provided the developmental stages are known.

The so-called retrogression, which takes place when Man and his domestic animals are allowed to work their will on a forest in a forest climate, has shown in all studies undertaken by ecologists that the effect of an increasing incidence of grazing upon an area is to reduce the vegetation to a succession of stages each of which is fairly well marked. All grazing animals—sheep, goats, cattle, camels—have their likes and dislikes and their effect upon vegetation tends to eliminate the more palatable kinds of fodder. Goats are probably the most dangerous of all browsers as they seem to be able to stomach most green plants. A combination of these animals is capable of reducing a community of vegetation to a desert. Paradoxically in certain parts of India the direct effect of overgrazing may be the creation of a type of forest. This occurs in certain areas where species of *Euphorbia*, distasteful to cattle and goats, are avoided and everything else browsed, leading to the local dominance of the *Euphorbia*.* A similar effect has been observed in Bengal where that interesting plant, *Careya herbacea*, has come to occupy considerable areas formerly occupied by grassland. Overgrazed areas in the Central Provinces are invaded by the weed *Xanthium strumarium*.

* An interesting feature of this stage is that the existence of the *Euphorbia* may lead to the appearance of tree species which are protected from browsing by the prickles on the *Euphorbia*.

Usually, however, excessive grazing leads to the establishment of undesirable types of grass whose adaptations against destruction are the prostrate habit and the production of prickly fruits which make them unattractive to cattle. The final stage is, of course, where even the grass cannot grow and its place is taken by undesirable weeds or even by blank areas. Nor is the creation of blank areas the only evil resulting from overgrazing. Once the soil cover is lost erosion may start and become a very serious problem.

What is the solution of the grazing problem in India? This is a question which is occupying a good many brains to-day. Overgrazing—a term which means the maintenance of a number of cattle upon an area which is too small to feed them adequately—has reduced the productivity of the usual grazing ground to a degree that the cattle remain in a state of semi-starvation. The owners of the cattle naturally turn their eyes towards the reserved forests where it is mistakenly believed immense quantities of grass are to be had.

For forests in which Government has decided that grazing is to be provided or in other forests where the Forest Department has decided that grazing can be allowed, the working plans contain some paragraphs which lay down the procedure to be adopted to control the grazing and improve the existing stocks of grass. The problem is not only quantitative but qualitative. The difficulties will be realized when it is pointed out that the ecological conditions necessary for growing good timber are diametrically opposed to those necessary for the production of grass.

Most proposals for the improvement of the grass crop in forest are some kind of closure. Here again certain difficulties arise. If grassland is seral in status, closure will inevitably mean progression towards the climax, that is, the disappearance of the grass and its replacement by some kind of higher vegetation. In this respect we require to know the speed of the progression and its stages.

It has been said that closure to grazing increases the proportion of palatable grasses. This may be true in certain areas but need not be true for all. The most palatable grasses are the soft-stemmed and soft-leaved grasses which are often annuals. The perennial habit, on the other hand, leads to the production of fibre and, of necessity, a reduction in palatability. Closure will not, I am convinced, lead to an increase in annuals but to a consolidation of the perennials and eventually, of course, to the disappearance of grass. A great deal more research is necessary before we can consider our grazing troubles as over.

Incidentally I may mention here that the odds against the success of any fast-growing and high-yielding exotic grasses are all but decisive. Unless such grasses are helped against the forces of progressive succession there is little hope of their survival. On the other hand, intelligent cultivation of such exotics and their storage by ensilage methods may lead to some betterment of the situation.

Another problem, mainly ecological, is that of

(*d*) *Erosion.*

'Geological erosion' or 'denudation' is the important process which, acting over thousand of years, is responsible for the present-day outlines of the hills and foothills and to a large extent for the deposits of soil in the plains. This process when left to nature is a slow and beneficent one but when it is hastened by the interference of Man becomes one of the most destructive known in the history of the world.

The earliest stages in the formation of soil can be seen to-day in rocks covered with lichen or alga. The process of weathering breaks down the rock and eventually a series of plant communities, varying in complexity from the original algae or lichen up to the stately coniferous or evergreen forest, takes possession of the soil. The factors influencing soil formation are climate and vegetation. It has been found that mature soils, developed on smooth flat or gently sloping surfaces and existing for a long time undisturbed by erosion or deposit or Man's activities, owe their essential characters to the climate in which they are developed [31]. Hence all stable mature soils in a given climatic region tend to show similar profiles. I have said above 'undisturbed by erosion or deposit'. This is not quite true, for there is always some slight denudation going on even in a forest-clad area. The earth, as it were, is always shedding its skin and a corresponding thin layer of soil is being added by weathering of the rock below. In a forested country, or in grassland, where this type of vegetation is the climax, there is always some slow removal of the soil. As long as this is gradual and slow, no harm is done, some rugged or sharp contours are merely smoothed away. In this way an equilibrium is reached between denudation and soil formation so that, unless the equilibrium is disturbed, a mature soil preserves a more or less constant depth and character indefinitely [32]. This remark applies even to the most friable of soils, such as recent alluvium, provided the covering of climax vegetation is maintained intact.

I have already touched upon the fertility that is built up even in initially unfertile soils, by the process of reaction. This fertility, I have also mentioned, is turned to Man's advantage by the noxious practice of shifting cultivation. After the hill field is abandoned, cattle, goats and sheep prevent the return of the forest and the area remains as pasture. In order to procure an early flush of tender grass shoots the herdsman makes use of fire, which delivers the goods in the form of tender grass.

but effectively prevents the germination and growth of tree and bushy species.

In areas where the rainfall is heavy and, therefore, likely to do damage to the exposed soil, the natural climax is forest, in areas of less rainfall, bush or xerophytic scrub of some kind. In other words, no matter what the climate, the climax vegetation which is developed is sufficient to prevent erosion.

In a forest climax the heavy rainfall is held up by the dense vegetation and only removes a minute amount of the soil, but if that forest is reduced to grassland through man's activities, then the same rainfall is not held up but runs from the surface and will remove large quantities of soil. Still greater will be the danger if the grassland is overgrazed, for the soil is exposed and trampled into paths which act as natural lines of drainage and are potential foci for development of gully erosion.

Once Man has interfered with the vegetative covering of the soil, the slope of the soil and the nature of the soil are the more important factors.

Water is not the only agent which is the cause of erosion. Wind, too, is a very destructive agent. The great dust-storms which have swept over the American prairies in recent years, removing thousands of tons of pulverized soil and creating havoc over immense areas, provide the classic example of wind erosion following the misuse of land. In India the main erosion agent is water but wind is active as well and the well-known 'Loo' is laden with fine dust. As in the case of water erosion, wind erosion is due to the removal of the vegetation by the activity of man.

In India the most pitiful example of misuse of land is seen in the Punjab Siwaliks. Man has been very active with axe and fire for many years in the Punjab in order to obtain fields for cultivation and grazing for his cattle. The removal of the climax vegetation, followed by continued grazing, initiates a vicious circle. The soil loses its fertility and will not support the climax species; this again leads to further erosion and further loss of fertility where even the secondary species will not grow and so on down to bare rock where only the pioneer species can ecise.

We have seen that one of the consequences of erosion is a loss of fertility and loss of soil stability. A further consequence is a reduction in the water-holding capabilities of the soil. In soil covered with vegetation, the upper layers, impregnated with humus, act as a sponge and absorb and hold water which would otherwise flow along the surface. This water is then released slowly to the underlying layers. Should the humus-impregnated layer be removed rain-water flows off the surface and leads to sheet erosion and eventually to gully erosion.

The water supply of any region is intimately bound up with the drainage system as carved out by nature. When the drainage area is covered with forest the rainfall is held up and is gradually discharged into the streamlets, then into streams and so on into the rivers. In well-forested areas the streams are perennial and the amount of silt removed, even in the heaviest rainfall, is slight.

Now, if sheet erosion has occurred, water, which in the usual course of events would be stored, runs rapidly off the surface removing further quantities of soil and results in a very large quantity of water being discharged in a very short time. This naturally leads to floods and a dislocation of water supplies.

It is this very danger which is ever present in areas where hill cultivation is allowed, and one would have thought that this aspect of denudation was well understood. Such apparently is not the case. Some years ago a conference of hill officers was asked to consider the reservation of certain areas as protected forests, in order to minimize the danger of floods, as it was considered that these were in no small measure due to the shifting cultivation practised in the hills. In rejecting the proposal, these officers recorded their opinion that the floods in the plains were not due to denudation in the hills but—and here comes the master-stroke—were due to the activities of the plains folk themselves. The argument was that the plains-dwellers cut down grass and the tree jungle which would otherwise have held up the flood water !

You may very well ask what bearing all this has upon ecology. The ecologist (represented by the forest officer) is often called upon to advise in the matter of afforestation of badly eroded lands and his hands are usually tied by the imposition of impossible conditions such as that grazing must be allowed and lopping of trees permitted. The ecologist is asked to grow trees upon land which has been denuded to such an extent that it is fit only to support the pioneers of the sere. Unless the subject is studied ecologically it is impossible to say what are the stages of the sere and whether it is possible to take a short cut to the appropriate climax type, which, it may be remarked, is the only type of vegetation which will prevent erosion without artificial aid from Man.

The only cure for erosion is the conservation of the soil, in the first instance by artificial means and then by replacing the cover of vegetation. Very often the only plants which will grow on badly eroded soil are the pioneers of the bare areas of such regions and it is useless to expect valuable trees to grow on unfertile soil.

The most desirable activity is, of course, the devising of some technique which will enable the land to produce the crops needed by the inhabitants without exposing it to erosion. Such techniques are being evolved in many countries of the world on an ecological plan.

Conclusion.

A recent book [33] begins with the words 'To gain control over the soil is the greatest achievement of which mankind is capable' meaning thereby that only when the control of the soil has been wrested from Nature can the stable * structure called civilization be erected on the land. During the past two or three centuries Man has spread all over the world and has taken possession of the soil. It can be said with truth that he has wrested the control of the soil in many places from Nature but it may be doubted whether the change of control has been for the better.

In many parts of the world to-day, simply as the result of human mismanagement, the thin layer of fertile soil has been, or is in the process of being, washed or blown away. Not only is this the case but mismanagement in one area may bring flood and havoc to another. One may say with perfect truth 'Man's mismanagement of land makes countless thousands mourn'.

If these and kindred problems which have arisen from Man's contact with the biome or ecosystem are to be solved in a proper manner and within a reasonable time, it is clear that they must be viewed from the ecological angle and dealt with upon an ecological basis. Moreover, if we do not propose to hand over to our descendants a situation which is insoluble, it behoves us to consider carefully any activity of man which may disturb the vegetative cover on the soil. In other words, the ecological consequences must be foreseen and allowed for.

All our ecological problems can be correlated with the different meanings and implications of the word 'conservation'. Any activity of man which deals with the conservation of soil, of vegetation, of water supplies, etc., must imply a thorough understanding of the fundamentals of the theory of vegetation and ecology.

Take the following fields of human activity and endeavour: forestry, agriculture, grazing, land classification and planning, management of wild life, anthropology, social science, medicine and epidemiology and many others of like nature, in which the reactions and coactions of living things upon one another lead to certain states and raise certain problems—I submit to you that the only logical approach to these problems is the dynamic one of modern ecology.

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* I use this word with the greatest diffidence at the present time when civilization appears to be anything but stable.

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SECTION OF ZOOLOGY

President :—H. SRINIVASA RAO, M.A., D.Sc., F.A.Sc., F.N.I.

Presidential Address

(*Delivered on Jan. 5, 1942*)

THE URGENT NEED FOR BIOLOGICAL STATIONS IN INDIA

My first duty as President of this section is to thank you for electing me to this distinguished office. Looking back over a period of eleven years during which this section had been presided over by distinguished professors of our universities, I feel how little worthy I am to occupy this Chair. By profession I am a systematic zoologist, concerned with the naming and classification of the shrivelled carcass of Invertebrate animals, a dabbler in species which is 'no hard glistening tangible thing like the atom of classical physics' but which is 'rather like the Schroedinger atom, a thing of mistiness and lack of definition'. The choice of a subject for the Presidential Address has therefore been no easy matter for me. I was aware of the general convention of confining the Presidential Address to a review of the progress of knowledge in a particular branch of Zoology with which the President himself was well acquainted, but I have decided to follow some of my predecessors in departing from this practice firstly because I can lay no legitimate claim to being a specialist in any branch of Zoology, and secondly because a review of this kind for the whole field of Zoology in India had been published on the occasion of the Silver Jubilee Session of the Indian Science Congress less than four years ago.

In choosing the subject for the present address, the two most weighty considerations which prevailed on me were (1) the importance of Biological stations to the advancement of fundamental knowledge in Biology, and (2) the value of this knowledge as a constructive factor in the progress of human civilization. During the last thirty years distinguished biologists in India and elsewhere have from time to time directed attention to these considerations with special reference to Indian conditions, but there is no evidence that this fact is widely known to the educated public in India. The views expressed by them are either published in little known bulletins and journals or lie buried in musty old archives of Governments with which they were connected. I propose to devote this address to a brief historical review of the facts relating to the efforts made by our illustrious colleagues to establish Biological stations in India in the years that have passed by, and to an examination of the probable causes of failure to achieve our object with a view to assist in the solution of our difficulties.

The question of a Biological station for India came up as long ago as 1911 in connection with the expansion of the Marine Aquarium at Madras which had been opened two years earlier. Sir Frederic A. Nicholson, the then Hon. Director of the Madras Fisheries suggested to the Government of Madras in this connection that the new aquarium '(*a*) should not be merely a show place for recreation or for the satisfaction of curiosity even though intelligent but that it should be (1) scientific, (2) educational, (3) practical, and (*b*) that the direct association of "Fisheries" with the aquarium will be for the financial, administrative and practical benefit of both'. He stated further that 'the contents and biology of the tropical waters of the Near and Middle East are scientifically almost unexplored; we know almost nothing of Marine Zoology in its many living aspects as apart from mere descriptive and classificatory work. Apart from the aid which science may and does give to practical work, there ought to be in this great country, the very centre of the tropical East, a central station, where the marine fisheries staff and where savants and students of Marine Biology can study marine life, both fauna and flora, not as mere museum specimens but as living organisms. A marine station where college students can study, as living organisms, the fauna and flora which their textbooks describe, can observe, handle, and dissect them will be of first class educational importance. An aquarium which is at the same time a Biological station would be of great practical importance, especially to the "Fisheries" staff. Marine fish-farming, for instance, can hardly be undertaken successfully or without much loss of time and money, until we know at least something of the breeding and feeding habits or characteristics of food-fishes on which, at present, we know absolutely nothing; these points could be readily studied in an aquarium properly equipped for such studies and continuously available to Fishery officers. Madras established the first tropical aquarium—except that in Honolulu—and has already shown therein some of the wonderful animals which live in its waters; now that the aquarium is to be developed in size it should also be developed in scope, in importance, and in usefulness'. Sir Frederic recommended on the basis of Mr. Hornell's plans that the whole upper storey of the new aquarium should comprise a good laboratory, a technical museum, and library for the use of students and staff, and office rooms, while the whole of the ground floor should be reserved for the aquarium proper. These proposals were approved by a committee of four fishery and educational officers of which Sir Alfred Gibbs Bourne, the Chairman of the Committee, was one. In 1913 the Madras Government approved the recommendations of this Committee and sanctioned the scheme at a cost of two lakhs of rupees, and a recurring grant of Rs.12,300 for the maintenance of the station. Orders were issued to the P.W.D. for the preparation of detailed plans and estimates for the work, and for the transference of the control and management of the station from the Education to the Fisheries Department. Proposals for the expansion of the existing aquarium at Madras and for the construction of new aquaria at Rameswaram and Vizagapatam in connection with the work of the Fisheries Department were submitted from time to time during the last few years, but the Government of Madras have deferred giving effect to them. The Madras aquarium therefore still remains the only one of its kind in the Province and essentially a show place for the general public deriving an annual revenue of about Rs.8,000, and the scientific activities of the Department are mainly confined to Calicut on the West Coast and to Krusadai in the Gulf of Manaar, stations where up-to-date facilities for sustained biological work are not yet available.

On his return from a deputation in Europe to study the organization of marine Biological stations, Dr. Stanley Kemp, the then Superintendent of the Zoological Survey of India, drew up a detailed scheme for the establishment of a marine Biological station at Port Blair in the Andaman Islands and submitted it to the Government of India in 1920, strongly supported by the Board of Scientific Advice to the Government of India and by the British Association for the Advancement of Science. According to these two influential scientific bodies, the scheme was sound from the zoological, botanical, hydrographical, and educational points of view.

From a purely taxonomic point of view it has been shown in Europe, America and Japan, and more recently in India, that it is necessary to take into account the development, environment and adaptive characters of organisms in addition to the structure as elucidated in the examination of preserved material. This view can be rendered practical only in a Biological station in which animals can be studied in their natural surroundings. All animal life in the sea ultimately depends on the abundance of minute organisms of a vegetable nature. Of the larger forms known as sea-weeds practically nothing is known in Indian seas, not to speak of the many different kinds of the blue, green and red algae amongst which are the forms concerned with the formation of certain reefs. A detailed study of the botany of the sea is therefore very essential. Hydrography has undergone great development in the Atlantic and the Pacific, but in Indian waters extremely little is known of it except what has been studied by the Surgeon-Naturalist on the 'Investigator' who had no opportunities for work in a properly equipped shore station. The study of salinities, temperatures, currents, etc. on board the ship can only be satisfactorily carried on when it can be correlated with observations made in a well-equipped scientific shore station.

One of the strongest arguments that can be brought forward for the foundation of a marine Biological station is the facilities that it would provide for team work between experts of different branches of science. The advances made by the International Council for the Exploration of the North Sea owed much to such team work in the marine Biological stations in Europe without the help of which fruitful results would have been impossible. The fishery problems to be faced in the Indian seas are far more varied than in the seas of Europe where the experience gained through centuries of fishing had brought together a vast amount of practical knowledge which quickened scientific investigations. No such accumulated knowledge is available for Indian waters in the study of fishery problems, and it is all the more necessary that adequate facilities should be available for the correlation and analysis of information from local sources. The life-history of no important Indian fish has yet been worked out, and European Biologists who are acquainted with Indian conditions rightly attribute the lack of this knowledge to the absence of Biological stations in India. Nothing is known of the food, migration, and enemies of even the most important species of food-fish in our seas. All these can be investigated adequately only in a marine Biological station. What has been said above of fish applies with equal force to shell-fish, bêche-de-mer, sponges, corals, sea-weeds, etc., which provide not only food for the people but also important commercial products. Lastly, no fishery legislation that is not based primarily on knowledge gained of the fish concerned will be of practical value.

The Indian sea-fisheries are in their infancy still and commercially inferior to those of Europe or America. They have great possibilities and it is necessary that scientific research should proceed side by side with commercial exploitation. There are economic problems in the solution of which the facilities available in Biological stations alone would prove of great benefit.

The value of a course for students of Biology at a well-equipped marine station is recognized by all European, American and Japanese universities, and every encouragement is given to students to visit some Biological station during their long vacations. In India on the other hand there are no real facilities for the students except those that can be had at Krusadai Island near Rameswaram or for practical training of fishery students except such as is available in the Madras Fisheries—not to speak of the lack of facilities for research in Marine Biology. As regards supply of biological specimens the only facilities available in India for universities teaching Biology are those provided by the Madras Fisheries Department.

The British Association whose enthusiastic support of the Port Blair scheme carried with it the promise of expert advice on organization and equipment of the station learnt with regret that the scheme had been put in cold storage owing to financial stringency.

The deficiency in our equipment for biological teaching and research did not fail to stir individual minds in this country connected with the teaching and research professions. Dr. K. N. Bahl of the Lucknow University, President of the Zoology section at the Bangalore session of the Indian Science Congress in 1924, devoted his presidential address to the organization of zoological teaching and research in India, emphasizing this deficiency. Exactly ten years later Prof. P. R. Awati, Professor of Zoology at the Royal Institute of Science, Bombay, presiding over the Zoology section of the Science Congress at its Bombay session in 1934, put forward a vigorous plea for the compulsory teaching of Biology in the primary and secondary schools in India as the only right step towards the diffusion of biological principles and facts among the masses in this country.

In alluding to the then proposed Indian Zoological Memoirs on the lines of those published by the Liverpool Marine Biological Committee, Dr. Bahl thought that if a well-considered scheme for a marine Biological station was put forward the universities in India would help such a scheme. He also felt it advisable that, in view of the size of the country, we should have two or three stations. You are no doubt aware how this address was followed by an interesting discussion by the members of the Botany and Zoology sections of the year on the need for a marine Biological station for India which led to the unanimous passing of four resolutions. The first resolution endorsed the plea for immediate action in regard to the inauguration of a scheme 'for marine Biological stations where students and approved workers can obtain a practical knowledge of marine organisms and do research work as they do in the stations attached to every university in Japan, as well as in England and elsewhere'. The second endorsed the view that Krusadai would be 'the most suitable and convenient place for the establishment of such a station to meet the needs of the universities of Madras, Mysore, Travancore, Bengal and probably Benares and some other universities in N. India'. The third resolution endorsed the opinion that a second Biological station should be established at Karachi, primarily for the use of the universities of Western and N.-W. India. The fourth requested the Hon. Secretaries of the Congress to communicate the above resolutions to all the Indian universities and the local Governments and Durbars.

Colonel R. B. Seymour Sewell, Director of the Zoological Survey of India and President of the Zoology section of the Lahore session of the Indian Science Congress in 1927, speaking on the subject of the *Study of Zoology in India in the Future* referred to the 'absolute necessity of carrying out systematic investigations regarding the Ecology and Bionomics of the marine fauna'. In other countries the realization of this necessity has led to the 'establishment of numerous marine Biological stations and the appointment of a large staff of marine biologists. Even in the little island of Ceylon this necessity has been recognized and the work carried out under the Ceylon Government has resulted in the formation of a company to exploit, by means of sea-going trawlers, the fish supply of the Ceylon and of our Indian coasts. In India the maintenance and improvement of our fish supplies, whether from the coast or from inland waters ....are all problems in Zoology and can only be solved by the application of zoological research and zoological methods'.

A few months before this address was delivered at the 1927 Science Congress Col. Sewell had planned the establishment of a marine Biological station at Karachi in his 5-year scheme for the expansion of the Zoological Survey. Karachi had been substituted for Port Blair (in Dr. Kemp's scheme) after due consideration of various circumstances not the least of which were the accessibility of the station to research workers and students of Indian universities, more particularly those of Bombay, Nagpur, Lahore and Agra, and the development of an already existing flourishing fishing industry on the coast of Sind. The income from the sale of biological material from this station to universities, colleges and schools, and from admission fees to the public aquarium would meet part of the expenses of the station. The Karachi scheme included the appointment of (1) a whole-time Marine Biologist to supervise and run the Karachi station and to conduct research on the faunistic and allied problems, and of (2) a Chemist to study the periodic and seasonal changes in the physical conditions of the sea-water on which the distribution of the fauna depends. Owing to various circumstances, not all of which were beyond human control, the Karachi scheme of 1926 shared the fate of the Port Blair scheme of 1920.

Progressive ideas, from whatever source they emanate, have a way of overcoming difficulties created by the innate conservatism of man and his institutions. Away, in the so-called benighted Presidency of Madras arose, in the year 1927, the humble zoological research department of the Madras University located in a single room of the dilapidated old building known as the 'Marine Villa' where one or two students were engaged in systematic and planktonic studies under Professor (now Sir) K. Ramunni Menon, the Honorary Director of the department. From these humble beginnings the department grew into a first class research laboratory in 1933 in a new building of its own with half a dozen research workers and a whole-time Director. The work in this laboratory is mainly marine biological and is similar to that carried out at the Plymouth Station except that there are no circulating aquaria and no facilities for hydrographical investigations. Under the Directorship of Prof. R. Gopala Aiyar the Madras University Zoological Laboratory has in less than a decade contributed nearly a hundred papers dealing with various aspects of the marine and brackishwater fauna of Madras and its environs, a record of which any institution of a similar kind in Europe or America may well be proud. A scheme for building a one-room laboratory at the entrance to the Madras Harbour with circulating sea-water and other facilities, and a motor-boat attached to it for collection purposes was under consideration by the Madras University, but owing to the present war this matter has been shelved indefinitely.

As President of the Zoology section of the Indian Science Congress at its Patna session in 1933, Prof. Gopala Aiyar in the course of his address on 'Some aspects of Marine Biological Research' referred at length to the necessity of having an All-India Marine Biological Station and outlined a scheme of maintenance of the station if one was established. At the same session the Zoology and Botany sections of the Congress held a joint discussion on the subject and appointed a committee of five biologists to work out a practicable scheme and suggest the ways and means of raising the requisite funds.

Since 1930 Dr. S. B. Setna, Fisheries Officer of the Industries Department, Bombay, has been keenly interested in the establishment of a marine Biological station and of a Public Aquarium at Bombay. His example in directing public attention to the value of a Biological station and Aquarium in scientific journals such as *Current Science*, has been followed by eminent zoologists both in India and England. Col. Sewell and Professor B. L. Bhatia in India, and Professor J. Stanley Gardiner of Cambridge and Professor W. M. Tattersall of Cardiff in England contributed articles to the *Times of India* and other influential daily papers of Bombay urging the establishment of a marine Biological station in that city. The *Evening News of India* in its issue of February 19, 1938, editorially commented on the need for such stations in India in the development of the fishery industry. Dr. Setna has been making special unofficial efforts to interest influential business magnates and trustees of charitable institutions which bear the name of Tatas, and trusts of the opulent Parsi community of Bombay, of which he himself is a distinguished member, in his scheme for a marine Biological station in that city, but there is up to now no clear evidence of a sympathetic and encouraging response which would help to launch the scheme even on a modest scale. It is to be hoped that the great House of Tatas whose abiding interest in schemes promoting general education and culture in the country is so well known will, in the near future, take up the cause of biological education by supporting whole-heartedly Dr. Setna's scheme for a marine Biological station in Bombay.

In 1938, Dr. Stanley Kemp, presiding over the Zoology section of the Cambridge meeting of the British Association, pleaded for the establishment of well-equipped Biological stations in the tropics. As an officer of the Zoological Survey of India for fourteen years with a wide knowledge of tropical zoology, as leader of the Colonial Government's R.R.S. *Discovery* Expedition, and as Director of the Plymouth Laboratory, his authoritative voice deserves a respectful hearing in every civilized country. 'In many biological studies,' he stated, 'we are now reaching a point where observations on other faunas are essential to further progress, and a well-equipped tropical station in one of the richest areas of the Indo-Pacific region is rapidly becoming an urgent necessity .... It is no exaggeration to say that in Africa and throughout almost the whole of the vast stretch of the Indo-Pacific region there is scarcely a fish whose life-history is fully known and whose various stages from egg to adult can be recognized. Of such matters as age, rate of growth, spawning periods, food and migrations we are equally ignorant, nothing is known of the incidence of fluctuations and nothing of the seasonal or other changes in the environment. It is surely time that the importance of such knowledge was recognized and that early steps were taken to lay the foundations of fishery science throughout the Empire.'

The persistence with which the question of establishment of a marine Biological station for India has come up during the last ten years before the Zoology section of the Indian Science Congress in particular and before the Congress as a whole is an indication of the realization by biologists in this country of its importance and urgency. It came up for discussion again before the Zoology section at the Madras session of the Congress in 1940 and later in the year before the Executive Committee of the Indian Science Congress, but in the absence of any authoritative mandate from universities, scientific societies, and Governments who alone are in a position to finance a scheme of this nature the delegates of the Biology sections of the Congress have helplessly drifted in an ocean of pious hopes without achieving any tangible results. In the meantime Travancore has stolen a march over the rest of India in establishing a marine Biological station at Trivandrum both for teaching and research.

Let us for a while consider how other nations of the West and the East have succeeded in establishing a string of Biological stations where we have failed. Europe alone has over 75 stations large and small, permanent or temporary, fixed or floating, marine or freshwater, from Archangel on the Arctic Ocean and along the coasts of the North Sea, the English Channel, the Bay of Biscay and the Mediterranean, to Varna and Sebastopol on the Black Sea. Heligoland, Plymouth, Monaco and Naples are the best known of the European stations. Although the credit for establishing the first Biological station of the world at Concarneau in 1859 goes to France, the peer and leader of all Biological stations in Europe is Naples founded by Anton Dohrn in 1872, which largely influenced the establishment of many other stations in Europe between that year and the first decade of the twentieth century. The Committee of the British Association for the Advancement of Science of which Anton Dohrn was a member had as its aim the establishment of Biological stations all over the world, an aim which, as events have shown, has been largely realized except in the Middle East of which India is a part.

Between Ghardaqa on the Red Sea coast of Egypt and Hong Kong on the Chinese coast there is at present only one marine Biological station at Trivandrum financed by the Travancore University, the youngest of Indian universities, established in 1938. The Baroda Government have had a scheme for a marine Biological station at Port Okha on the Gulf of Kutch under consideration during the last three or four years, but their efforts do not appear to have achieved any tangible result up to now.

With whatever aims Biological stations have been founded in Europe and the United States of America, they have, as a rule, received ungrudging financial and moral support from their respective States, universities, scientific societies, fishery associations and guilds, municipal or other self-governing bodies and public-spirited businessmen or scientists. The realization that adequate instruction in biological sciences can be given only at the sea shore in direct contact with the life of the sea has been responsible for the phenomenal growth of Biological stations in France which has perhaps the largest number of stations among European countries. The scientific work of the fisheries of France has been associated throughout with the Biological stations and the biological faculties of the universities which controlled the Biological stations. The functions of teaching and research are combined in many stations. More or less similar conditions prevail in Great Britain and Ireland, Germany and other countries of central Europe, Scandinavia and U.S.S.R. with emphasis laid on pure or applied research or on both. The supply of biological specimens, live or preserved, and even of sea water to schools and colleges, museums, field clubs, societies of naturalists, individuals, and commercial aquaria with little or no profit forms part of the programme of many Biological stations in which instruction or research is the chief aim. The value and usefulness of this aspect of biological activity has been so firmly impressed on some of the European countries that private corporations, of which the one on the Istrian coast of the Adriatic is the best example, were founded to meet the demand for the supply of biological specimens. During vacations and other convenient times students, research workers, teachers and professors have flocked to the biological stations to avail themselves of the opportunities of studying life first hand in the seas, lakes and rivers and of utilizing the knowledge thus acquired for the benefit of humanity. That these opportunities are not being fully utilized is deplored by influential scientific organizations even in the more advanced countries of Europe.

In Japan Biological stations have been founded by the State in quick succession as part of a general policy of intensification of higher education. The Imperial University of Tokyo has had a marine Biological station at Misaki for nearly fifty years intended primarily for the use of its students and professors. The course in Biology requires the students to spend at least one season in the station, and those who take up Zoology as their special subject have to spend much more time there than at the University laboratories on shore, and become familiar with the marine life at hand. The Japanese Government did not allow preoccupations with the Sino-Japanese war of 1894-95 and the Russo-Japanese war of 1904-05 to interfere with their schemes for educational expansion. After the first Sino-Japanese war they established the second Imperial University at Kyoto, and after the Russo-Japanese war the Imperial universities of Kyushu and Tohoku, and after the first world war the Hokkaido Imperial University. In the Imperial ordinance relating to the organization of the Hokkaido University it was laid down 'that there shall be a marine Biological station attached to the Faculty of Science', which shows how much importance the Japanese Government and the educational authorities attached to the establishment of Biological stations. Marine Biology including Planktology is part of the subjects prescribed for a course in Agricultural Biology under the Faculty of Agriculture. Three hours per week each semester or term is compulsory for this course. For the fishery course, special lectures on aquatic Biology for eight hours a week per term excluding three hours for laboratory work are obligatory. In the Faculty of Science Marine Biology is a compulsory subject for all students of Biology. In connection with the expansion of the activities of the Japanese universities, several other marine Biological stations including those of Seto and Asamushi have come into being within the last two decades liberally supported by funds provided by the Government.

Very recently the Colonial Development Advisory Committee of Hong Kong recommended a grant of £10,000 to cover the cost of the erection and equipment of a small fishery research station and experimental aquarium on the island of Hong Kong. Despite the fact that the present war has interfered with the establishment of the station, the staff of the station working at the Hong Kong University have already begun publication of their results on the biology of the China seas. The primary object of the station is to study fishes of the South China seas and the technique of fishing employed by local fishermen with a view to the future benefit of the fishing industry. The skeleton staff consists of two competent men, one a distinguished Ichthyologist with considerable practical experience of Chinese fishes, of the fish-fry industry of China, and of the life-histories of pond carps, and the other an Invertebrate Zoologist. A research fellow with knowledge of chemistry to look after tanning of nets, preservation of fish and other connected topics, and an artist to look after the exhibits of the station museum are also part of the staff. Two student probationers have been appointed for three years who will spend much of their time at sea with the fishing fleets and will return to the fishing industry. They will investigate problems connected with trawls, long lines, junk construction, statistics, seine, etc., and will be trained in other fields as well so that their experience will be of value to them in their future. They will thus act as a link between the research staff and the fishing industry. The value of the research work of the station to the fishing industry is so well known to fishermen's guilds that they have offered to support two studentships. The different members of the staff are masters of all the different dialects of China from Hainan in the south to Manchuria in the north. This should facilitate contact between students of Marine Biology and fishermen along the Chinese coasts and the staff of the station.

These achievements in Marine Biology have been equalled, if not surpassed, by the detailed studies on Freshwater Biology in the countries of Europe and the Far East and in the U.S.A. The studies on the pelagic fauna of the Swiss Lakes, and on the biological features of the elevated lakes of the Alpine chain have resulted in fundamentally important contributions to the lacustrine fauna of high altitudes in Europe. The study of the biology of the lakes in Japan and other Asiatic countries and of the Great Lakes and rivers in the U.S.A. has been of no less value than that of Marine Biology. In large countries like the U.S.A., U.S.S.R., China, and India where the interior districts are several hundreds of miles away from the sea coast, the facilities for marine biological teaching or research are necessarily limited to those universities and institutions located on or near the sea coast, but the inland universities have corresponding advantages in respect of freshwater Biological stations.

There has hitherto been no reference to the future possibilities of freshwater Biological stations in India. The fascination for the colourful and the greater variety of life in the sea and the first flush of excitement over the unknown have overshadowed the drab but useful elements of the fauna of freshwaters. India has unrivalled opportunities to develop by scientific aquiculture the biological resources not only in the sea around her but also in the backwaters, estuaries, creeks, rivers and reservoirs in the much larger area of land surface within her geographical boundaries. The development of freshwater Biological stations should therefore go hand in hand with that of marine Biological stations. India has no large natural lakes to boast of, but has an immense number of freshwater tanks and reservoirs mostly created by the hand of man over a wide stretch of the country. The great artificial lakes or reservoirs formed by damming streams and rivers in Central India, Rajputana, Bombay, Baroda, United Provinces, Central Provinces, Hyderabad, Mysore and Madras are more or less permanent bodies of water which, judging from their general features, should abound in fish, fowl and a variety of minute organisms. We know practically nothing of the biology and physical conditions of these great sheets of water. Of the fauna and flora of the few natural lakes of Sind, Kashmir, Kumaon and Assam, we have perhaps some slight knowledge, but here again our ignorance of the physical conditions is no less profound than in the case of the artificial lakes.[1]

Fifteen out of the eighteen universities of India have Biology as a subject for their graduate or post-graduate courses. Of the four universities situated on the sea coast, namely, Bombay, Travancore, Madras and Andhra, the last-named alone has not yet instituted a course in Biology, while Travancore, the youngest of the Indian universities, is the only one which has a full-fledged marine Biological station. Madras, in spite of the excellent work turned out from its laboratory since its foundation, still lacks the facilities of an up-to-date marine Biological station. Bombay is still in the throes of the birth of a station. The inland universities have as a rule to look to the Madras Fisheries Department for the supply of biological material apart from what their professors and students can collect for themselves on the sea shore in the course of a few hurried excursions organized for the purpose. None of them has yet planned a freshwater Biological station under its auspices on one of the natural lakes or artificial reservoirs, or rivers within a few hours' distance by rail or road from its location. The wide range of climatic conditions in different parts of India necessitates the study of all bodies of freshwater, large and small, within the political boundaries of each province and State. The great reservoirs of Periyār, Mêttur, Krishnarājasāgarā, Marikanavê (Vānivilāsasāgarā), Sulêkerê, Pākhāl, Tānsā and Morrumsilli in Peninsular India, the backwaters of the West coast, and the Pulicat and Colair lakes of Madras, the *Talāos* or reservoirs of the Central India and

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[1] The policy of investigating the fauna of natural lakes in India and Burma initiated by the late Dr. N. Annandale, the first Director of the Zoological Survey of India, has been followed by his successors in the Survey, but in the absence of permanent or semi-permanent Biological stations on the shores of these lakes, the investigations have been more or less of a desultory character and confined to the purely faunistic aspects except in the case of the Chilkā Lake.

Rajputana States, and of the U.P., the Manchār Lake of Sind, the Loktak Lake of Manipur in Assam, the Chilkā Lake of Orissa,[1] and the high altitude lakes of Kashmir, Kumaon and Sikkim offer exceptional opportunities for limnological studies on a wide scale in India, more particularly for the universities far removed from the sea coast, whose financial resources may be utilized profitably for the establishment of freshwater Biological stations. The facilities for marine biological work which the Travancore University has provided at present and those which the universities of Andhra, Madras, Bombay, and Sind or Punjab may in due course provide for purposes of instruction and research may be availed of by the inland universities by mutual arrangement. Perhaps at a very much smaller cost to themselves the latter could, by giving annual subsidies or rentals to the former, secure facilities for teaching and research for their own staff and students.

Each university in India which supports biological departments should be required to utilize to the fullest its biological opportunities determined by its geographical position and other natural advantages. The Calcutta University situated as it is on the banks of a tidal river and at the head of one of the largest estuarine systems of the world should find it feasible to establish a Biological station on the Hooghly river, either floating or fixed, or on the Saugor island near the sandheads off the mouths of the Hooghly and Matlah rivers. The small collections of animals which the Hooghly Pilot vessels have been able to bring from the sandheads from time to time show that there is a vast unexplored and interesting field of investigation in Biology in the shallow silt-laden seas at the head of the Bay of Bengal within a few hours' voyage from Calcutta. Here can be studied the problem of migration of fish, crabs, and prawns which form such an important element of the fishery industry in Lower Bengal. The Andhra University, situated on the sea coast with an excellent harbour at Vizagapatam and numerous brackishwater lagoons within a radius of 20 miles, should find it profitable to inaugurate biological courses with a marine Biological station established at or near the entrance to the Harbour. The position of Masulipatam, an important old port of the East coast, between the estuarine systems of the Godavari and Kistna rivers should make this a suitable centre for biological investigation of the problems connected with the sea-fisheries. The seas along the coast have been shown by the R.I.N. *Investigator* to be rich in fishes which should be expected from the fact that the deep wedge of silt-laden waters holding organic detritus from land provides a fertile field for the growth of a large variety of fishes.

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[1] The Orissa Government scheme for a fishery research station on the shores of the Chilkā Lake is under suspension on account of the present war.

Investigations of this kind involving the study of a variety of factors such as meteorology, hydrography, chemistry, planktology should necessarily be spread over a long period of years, and such a study cannot be undertaken except in a well-equipped marine Biological station. The opportunities of the Madras University are more in the direction of pure marine biological research, and the tradition it has already set up in this respect may well be maintained. The projected expansion of the city aquarium of the Madras Fisheries Department should help both this Department and the Madras University. The important additions to the fauna of Krusadai which have been made in recent years and the facilities which this island and Rameswaram provide for students and Fishery officers should encourage the continuance of this station as a research centre not only for Madras but for the rest of India. The small biological department of the Annamalai University has already some good work in freshwater Biology to its credit, and the provision of a small freshwater Biological station on the banks of the Vellār or the Coleroon river would encourage useful work on estuarine Biology. From the Travancore University, which has a well-equipped Biological station suited for marine, brackishwater, and freshwater work, important results may be anticipated within the next few years from the researches carried on at this station. The value of observations on the biology of the extensive backwaters of Travancore with their valuable fisheries should not be overlooked, and the possibility of maintaining a sub-station on the Vêmbanād Lake, at Kumaragam for instance, may be explored. The biological staff of the college at Changanāchêri affiliated to the Travancore University may, from its advantageous situation not far distant from the Lake, find unrivalled opportunities to concentrate their attention on its biology. Mysore and Osmania universities have excellent opportunities of studying freshwater biology, and the huge reservoirs which the States of Mysore and Hyderabad have built for irrigation purposes may well serve as suitable venue for the establishment of Biological stations. The reservoirs of the Central Provinces provide similar advantages for the Nagpur University. The volume of work on marine animals which the Royal Institute of Science has turned out in recent years should strengthen the hands of Dr. Setna, Fisheries Officer at Bombay, and of the Bombay Natural History Society in their efforts to induce the authorities of the Bombay University to establish a marine Biological station at Bombay. The importance of the marine fisheries on the N. Kānarā and Ratnāgiri coasts suggests that the Province of Bombay should have another Biological station, preferably at or near Ratnāgiri or Karwar, devoted exclusively to fishery research.

The Zoological Department of the Punjab University which has not failed to utilize the facilities available for marine biological work at or near Karachi could organize a small field station or camp at that place for vacation courses. If the Government of India scheme does not mature in the near future, the Punjab University can gradually expand the activities of their field station to a full-fledged Biological station equipped both for teaching and research. The investigation of the limnology of the Kashmir lakes would lie within the scope of this university which should impress on the Kashmir Darbar the importance of establishing a freshwater Biological station on one of these lakes.[1] The U.P. group of universities comprising Agra, Aligarh, Allahabad, Benares, and Lucknow all of which maintain active schools of biological research should find it profitable to concentrate attention on the study of freshwater Biology. A freshwater Biological station at Allahabad at the confluence of the Jumna and the Ganges to study the biological problems of these two rivers would provide the most appropriate activity to the Biological Departments of the universities of the United Provinces. A similar station on one of the Kumaon Lakes under the auspices of this group of universities would also serve as a useful centre of instruction and research for their biological staff.

In my view, the marine Biological station planned by Dr. Kemp for Port Blair should have an international status like that enjoyed by Naples, and the co-operation of the Governments of Burma, Federated Malay States, Straits Settlements, Dutch East Indies and Ceylon should be invited. Its central situation in the Bay of Bengal, and the other advantages such as the great variety of fauna, the purity of sea water, and the accessibility from Indian and other ports bordering on the Bay should make the Port Blair marine Biological station one of the finest in the tropical East.

In this grandiose scheme, which you may be tempted to call utopian, every Indian university will have the advantage not only of teaching Biology, as it should be taught, in all its live aspects but also of providing facilities for research to its advanced students and teachers. By mutual arrangement the maritime and inland universities can exchange their respective facilities, so that both of them will have a broad perspective of the whole field of aquatic Biology which is so essential for a proper appreciation of the domain of life in its utilitarian and philosopic aspects.

You may legitimately raise the question—How are we going to bring into being a whole network of Biological stations all over the country when we have not succeeded so far in establishing even one station for all-India? This is the question which I set to myself at the beginning of this address when I said that it

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[1] The Zoology Department of the Punjab University is, I understand, conducting investigations at present on the fauna of these lakes. Its reports will be awaited with interest.

was my purpose to examine the causes of our past failures in this matter. My one and only answer to this question after considerable deliberation is that we biologists who are members of this Congress, and those interested who are outside it, have failed to convince the controlling authorities of our universities and our educational institutions, and our Governments that Biology as it is taught at present without direct contact with living animals has outlived its usefulness. Unless a fuller equipment in the shape of Biological stations is provided on at least as liberal a scale as for the physical sciences, the progress of biological sciences in the tropics will be greatly hindered, a result which biologists all over the world are bound to deplore as a setback to the general advance of biological knowledge. We have more than once discussed threadbare the need for Biological stations in India, we have passed resolutions to indicate our determination to have one, and some of us have individually spared no pains to get the man in the street interested in our projects. The Travancore University has no doubt broken the ice, and has given the lead to the rest of India in establishing a Biological station on up-to-date lines, but there is no certainty that the others will follow this excellent example. It will perhaps be too much to expect that the authorities of our universities and of our educational and research institutions will initiate new policies or sanction increased grants for existing branches of scientific study until they are convinced that the pressure brought to bear on them is the outcome of a genuine need. It is our duty as biologists not to be content with the mere passing of resolutions on the subject of establishing Biological stations, but individually and collectively to discuss the matter with the university authorities and representatives of Governments and to make it a live issue. There is no evidence, so far as I am aware, that this has been done. In the meagre published proceedings of the Inter-University Board which has met at more or less definite intervals during the last fifteen years, there is, as far as I am aware, no indication that any biological topic of importance has ever been discussed. Nor is there evidence that our scientific societies and academies have contributed anything to make the subject a live issue.[1] The Indian Science Congress Association, the Bombay Natural History Society, the National Institute of Sciences of India, the Indian Academy of Sciences at Bangalore, the National Academy of Sciences at Allahabad, the Indian Botanical Society, the Indian Entomological Society, the Royal Asiatic Society of Bengal, the Indian Association for the Cultivation of Science are at present probably the only few

[1] The Indian Science Congress has at present under consideration a proposal to send a memorial to all Provincial and State Governments and to the universities, and the Central Government for financial and other support in the establishment of an all-India Marine Biological Station.

influential bodies of scientific men which could lend support to a comprehensive scheme of establishing Biological stations in India.

The problem of finance in schemes of this nature is an all-important one, and past experience in this country has shown that it can be solved only when the schemes have gained the sympathetic and active support of Governments. Financial advisers must be convinced of the urgency of our needs, otherwise we have to face their unanswerable argument of financial stringency. The united voice of biologists, of academic bodies like those enumerated above, and of influential public men with a vision would, however, be hard to resist, and in my humble opinion, the next big step in our effort should be to organize a select body of influential scientists and public men representative of all scientific organizations and universities in the country to place before the Government of India (Education Department) for their consideration our case for improved facilities for efficient teaching and research in biological subjects.

It may appear to most of us that the present time is not propitious for taking this step. Possibly there will be a considerable lapse of time between the knock at the door and the opening of it, but there is, I hope, none who will not agree with me that we biologists must make ourselves heard and understood with sympathy. Even as the war is going on leading men of England have set themselves the task of hard thinking and concrete planning of the future problems of their country. We, who have so far, fortunately, been spared from the ravages of war, have far greater reason to be planning our future. The Government of India's decision to appoint a Reconstruction Committee with representatives of various Government departments including Education to survey post-war problems being a timely one, interested educationists, biologists, representatives of universities and scientific bodies, and influential public men should lose no time in bringing to the notice of this Committee the value of establishing a chain of Biological stations in close association with universities or scientific institutions in the country. Some of us, at any rate, may be prone to associate big buildings or structures with Biological stations and to conclude that we shall never be able to afford these luxuries. What is important in Biological stations is the equipment—boats, dredges, nets, aquaria, books, scientific instruments, and competent workers. Buildings to house the equipment are no doubt needed, but humble thatched structures as living and work rooms in a tropical climate like that of ours may often prove convenient, and will perhaps be preferred to stone, concrete or brick buildings. Many European Biological stations have grown to their present status from humble beginnings. Whatever funds universities can spare should be spent on essential equipment, rather than on buildings which are not a necessary mark of a Biological station. The work is important, and some little sacrifice in personal comfort may be worth making if by spending a little less on buildings a little more is saved for equipment.

It will not be within my competence or within the scope of this address to discuss the feasibility of introducing a graded system of biological education in our schools, the readjustment of the present curricula of biological studies for the degree and honours courses to our new needs, and the desirability of reducing the heavy burden on the teaching staff in the universities with a view to give them better opportunities for research work and thus enable them to become more efficient teachers. These and other kindred subjects are bound to come up for careful consideration if and when a new turn is given to our system of biological education by associating the work of Biological stations with that of our universities.

I thank you for the patient hearing you have given to this narrative of my dreams. If this narrative stirs you ever so little to positive, united action along the lines I have indicated, I shall not have dreamed my dreams in vain, for, before long and in our life-time, we shall have not merely one or two Biological stations in India but as many as there are universities teaching Biology in the country.

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SECTION OF ENTOMOLOGY

President :—D. Mukerji, M.Sc.

Presidential Address

(*Delivered on Jan 6, 1942*)

CERTAIN ASPECTS OF MORPHOLOGY OF INSECTS IN RELATION TO HABIT

Introductory

Insects make up more than half of the recorded species of animals and they directly affect the welfare of man as no other animals do. Born in a geological age long long past, they have witnessed the rise and fall of so many of the higher vertebrates anterior to man and having lived through the long evolutionary history of the earth and its denizens, they have evolved in their finer adjustments to the varying conditions of the earth, a bewildering pattern of form, structure and behaviour, the like of which is hardly to be found in any other living organisms. No wonder, the fascinating chapter of insect life has caught the imagination of man since very early time, and as the human mind probed deeper and deeper into the living world and the intricacies of insect life, the study of insects as a branch of science rose to be of supreme importance.

The applications of entomological studies could nowhere be of greater advantage to the economic prosperity of a people than in an agricultural country like India, where vast quantities of agricultural and forest products go to waste as the result of insect attacks, and millions of men and cattle succumb easily to insect-borne diseases. India, it may be noted, is a country which holds the monopoly of lac, an insect product, provides excellent facilities for the bee-keeping and till recently could boast of its extensive sericultural industry.

The varied insect fauna of India—a land with special climatic conditions in its different subregions, while offers an excellent opportunity of inquiring into the fundamental laws governing insect life, has likewise problems which are not easy of solution. An instance or two will clarify the statement.

Helopeltis theivora Wat., wrongly called the tea-mosquito, sporadically breaks into a pest, and, when favoured by murky weather, works such a havoc among the best crop of the year that the entire tea-plantation covering hundreds of acres of land with no other vegetation except the shade trees as in the

Jalpaiguri district, Bengal, presents a woeful spectacle of blackened ends of shoots scorched as if by sudden lightning. Again, at other times, the incidence is too small to merit the name of a serious pest. The cause of the sudden appearance or disappearance of the pest remains a mystery, and on the discovery of the cause hangs the success of a remedial measure. It is also questionable whether the draining of sap by the bug which makes punctures on leaf buds as they come out, or the introduction of a micro-organism during the feeding operation of the insect, causes the withering of the shoots. The cultural methods for the control of this pest are difficult to apply in tea gardens; some of the plantations are forty or fifty years old, and gradual replacement of aged plants takes years and years. The spraying of suitable insecticides such as will not affect the quality of the manufactured tea, has met with little success, because the insects lie concealed under the thick canopy of leaves, or run under the dense tea bushes, and the liquid sprayed has little chance of coming in contact with them. The hand-picking of the pest though a slow and imperfect method is therefore commonly resorted to.

In the field of medical entomology, the path also is not smooth, and one asks why a mosquito once a carrier of malaria is not always a carrier. A field naturalist interested in the Camponitini group of ants, being puzzled with the variety of geographical and local races, colour variation of callows and adult, inquires about the limitation of a species and subspecies, and the long list of synonyms of a species reads like a tale of discomfiture of a systematist, though really it is a chronicle of efforts toward perfection which the systematist aims at.

Entomologists having their difficulties naturally welcome the chance of meeting each other and discussing their problems, which the annual meetings of the Indian Science Congress provide for. For facility of interchange of ideas they yearned for a separate section of Entomology under the auspices of the Indian Science Congress. But this hope came to be fulfilled for a short while only.

A separate section of Entomology was created under the auspices of the Indian Science Congress Association on the occasion of the Silver Jubilee Session held in Calcutta in 1938. In 1940 and 1941 two more Sessions were held. It is a pity that this Session marks the end of the Section of Entomology as separate from Zoology and other applied Biological Sciences. Hereafter this Section is to be merged into the Zoology Section. This decision has been made by the authorities of the Indian Science Congress in connection with the question of re-grouping of subjects, in view of the difficulties of the administrative machinery that followed the multiplication of sections after the Jubilee Session.

Mr. Afzal Hussain, President of the newly created Entomology Section in the Silver Jubilee Session of 1938 in his beautiful inaugural address 'Entomology in India—past, present and future', set forth admirably the importance of entomological studies in India and gave a valuable résumé of the progress of entomological researches in India and the wide scope thereof. In 1939 Dr. Ram Krishna Ayar in his presidential address at Lahore in the Section of Agriculture, dwelt on 'Insects and their rôle in Agriculture' in his inimitable lucid style. In the Madras Session held in 1940 Dr. Hem Singh Pruthi, President of the separate Section of Entomology, gave a masterly review of 'Ecology and Control of Insects'. In the Benares Session held in 1941 Rao Bahadur Ram Chandra Rao, in his presidential address in the Entomology Section, made an important contribution in the field of economic Entomology by his paper 'Some observations on the periodicity of Locust invasion in India'.

During the short period the Entomology Section has been in existence, it has, therefore, amply fulfilled its purpose. A large number of original articles on pure and applied entomology were read and published. Important questions, like the Biological control of insects, the value of Systematic studies, and the position of Entomology in the Indian Universities, were profitably discussed. The Entomological Society of India was born under its stimulus. In the programme of the current session the important question of a national collection of insects has been tabled for discussion.

The formulation of a proposal for Quarantine laws to prevent the danger of introduction of injurious insects to India during these days of rapid transport, the foundation of a bureau of entomological information, the publication of a card index of entomological researches in India for the benefit of research workers, and the diffusion of entomological knowledge bearing on the practice of farming and agriculture through the vehicle of the vernaculars, should demand our careful attention.

Unfortunately, this is the last session of the Entomology Section, and by generously calling me to preside over your deliberations at this juncture, you have shown more love to a brother entomologist than justice to your cause. The illuminating addresses of my learned predecessors have amply justified the retention of Entomology as a separate section and if I have reiterated the value of entomology in my introductory remarks, it is more to plead in my humble way for the cause which lies nearest our hearts than merely to provide a prelude to my address of today. In pressing the claims of entomology, due note should, however, be taken of the danger of isolation attendant upon the splitting up of the biological sciences into narrow compartments, and the practical difficulty likely to be experienced by the Executive Committee of the Congress in running too many sections at its annual sessions. At best, let us hope that the reunion of Entomology with Zoology for the present will be a happy one, like the return of the Prodigal Son. Maybe, that in years to come, a way will be found to restore Entomology to its rightful place. In the meanwhile a middle course might be followed, and some of the functions of the Entomology Section might be carried on by the Entomological Society of India.

It is the duty of a sectional president in this Congress to speak on a subject of real scientific interest. The Congress lays no hard and fast rule as to the selection of a topic relating to a particular section. The only visible restriction seems to be the duration and the length of the address. With this freedom of choice, however, the writer feels like one wandering over a vast open space in a starlit night. The stars seem so near and intimate yet so far and so mysterious; the sky appears so dark and deep. He is lost in amazement at the immensity all round him. His feelings are much like that of the Ancient Mariner—water, water, everywhere, not a drop to drink. For relief he turns to the pole star, bright and clear, the one fixed point in the horizon. Being in the same predicament, face to face with the vast expanse of biological knowledge, I have selected for the theme of my discourse today, a chapter from Insect Morphology which yet remains fixed and bright, like the pole star, in the firmament of biological sciences, undimmed by the dazzling lustre of newer concept. Morphology is an observational and old science, and rests, therefore, unless the observations are faulty, on a solid foundation. Its importance needs no emphasis. An evolutionist, as much as a systematist, or a physiologist, has to lean upon facts of morphology. No one can proceed with the study of insects without gaining a knowledge of the comparative anatomy of the arthropods. Unfortunately, this branch has rather been neglected in India for the simple reason that entomology finds no place in the curriculum of the Degree or Post-Graduate Courses in the Indian Universities, and an agricultural or medical institute teaching economic or applied entomology has less time and scope for a full treatment of the principles of insect morphology or those of pure biology.

Since the value of entomology is generally assessed by the results of its application to material civilization, a plea is needed for turning to the one aspect of pure entomology, namely, morphology, while problems of economic or applied entomology await for solution.

Pure entomology like every other pure science is concerned in discovering fundamental principles, and is guided solely by pure reason and observation, and not by any sense of utility or commercial interest. All the same, these principles often lead to the production of goods of marketable value, and of such, as change the course of human civilization. It was not a vision of utility that urged Faraday to discover electromagnetic induction. Yet no dynamo, motor car could have been built without that discovery. Mendel's hybridization experiments on pea-plants, or the recent laboratory experimentation on the little fruit-flies, were made entirely in pursuit of knowledge. They were not dictated by any motive of increasing human happiness. Yet the laws of heredity based on these experimentations and deductions, find their application in the breeding industry, or in schemes for the betterment of the race. The study of the breathing habit and structure of spiracles of the mosquito larva, might have suggested the kerosenization of water for the control of malaria. What did Pasteur know of the silk-worms? But it was he who saved the silkworms from *pébrine* diseases and rescued the sericulture industry of France. It is said that Australia wanted to grow clover and imported the seeds. The crops were successful for a time but ultimately failed. The rescue came from the entomologist who perhaps might have been engaged in the thankless task of measuring lengths of the proboscis of insects, but whose suggestion of introducing the bumble bees which pollinate the red clover, met with the remarkable success.

If I have referred to these examples which are too well known to need any mention, it is not for the purpose of justifying the title of my address, or, its importance, but to give caution to the increasing tendency of evaluating researches by the standard of immediate usefulness, and lightly brushing away those which do not touch economic problems, as of academic interest only.

Really speaking, there is no sharp line of demarcation between pure and applied entomology, or rather it may be said that the two stand together in the relation of symbionts, one benefitted by the development of the other.

Morphology is known as the science of forms in the living organisms. Its scope as given by Dobzhansky (1937) can be summed as follows:—(i) recording of the fact of diversity as it appears to our senses, (ii) describing the diversity in terms of ideal prototypes, (iii) tracing the development of individuals (ontogeny), (iv) tracing the development of groups (phylogeny), for understanding of the present status of the living world through a knowledge of its past.

So far it is a descriptive and historical science seeking to understand the relationship of different forms to one another through structural resemblances and differences. If it be regarded more as concerned in the continuity of forms by the maintenance of equilibrium of forces governing the life of the organism, through the hereditary equipment of structure, it becomes a static science. The other side of the picture should not be lost sight of either, namely, the structural changes induced by movements, by reason of physical or biological changes of the environment, leading to the evolution of organs. In view of the correlation established in course of evolution between structure and function, the need of interpreting structure in terms of function as initiated by habit arising out of new needs, or induced by environmental conditions, becomes essential.

Certain physiological functions for maintenance of life are common to all, and these may be called basic functions. These, however, are carried in different groups of animals in different ways ; insects have their own way of doing these things, and they have their special structures too. The mechanism for performance of these gives the picture of the impact of forces upon the dynamics of life. Analysis of this, paves the way for correct understanding of the cause and effect: it also explains behaviour (Kennedy, 1927). It does not endeavour, however, to treat the ultimate causes, or, factors of evolution. That must be left to the domain of physiology or rather the realm of experimental zoology.

It is the physiological aspect of morphology, which I may be permitted to call functional or mechanistic morphology of insects, in relation to habit, that I desire to lay before you,—in reference to my own observations on the subject. In my account I have touched only the respiratory and the reproductive system of a few types selected from our insect fauna.

Respiratory System

Animals generally can live for a time without eating and drinking but never without breathing. Respiration, therefore, is of fundamental importance in the maintenance of life. The respiratory system in insects usually consists of breathing apertures called spiracles, and a system of air pipes called tracheae. The tracheae are non-collapsible tubes and their walls are permeable to gases (Wigglesworth, 1931). They are ectodermal in origin being formed by the invagination of the cuticle. Their finer capillary branches called tracheoles enter various tissues, or organs of the body. The tracheoles are laid as fine intracellular canals within certain cells which are detached from the general tracheal epithelium and grow out into finger-like processes toward the tissues (Wigglesworth, 1939). As the body cavity is permeated by blood, all the tissues are bathed by this nutritive fluid, which, according to Demoll (1928), cannot transport oxygen. Air is drawn through the spiracles and passes through the tracheae to reach directly the tissues, each tissue acting thus like a lung (Graber, 1877). The supply of oxygen to the various tissues is therefore made, unlike in vertebrates, without the agency of blood. Rapid oxidation of tissues all through the body, takes place speeding up the liberation of energy. This explains the intense activity on the part of an insect relatively to the size of its body. Carbonic acid gas formed as the result of the combustion of tissues, either diffuses with nitrogen, through the blood, to pass in small proportion to the exterior through the permeable portion of the integument (Demoll, 1928), or collects within the tracheae to be eliminated through the spiracles. The spiracles can open or close, independently of one another. Near the junction of the spiracle with the trachea, there exists a closing or occluding apparatus for control of inlet and outlet of air.

Insects in their organization of the respiratory system show varied adaptations to environmental conditions. I shall take first an example from the aquatic Dytiscid beetles which are considered to be derived from land beetles, to illustrate the correlation existing between habit and structure in particular reference to respiration. The species of *Dytiscus* has been used for study by numerous authors (Wesenburg-Lund, 1912; Korschelt, 1924). The genus *Dytiscus* is not represented in India, but its place is taken by *Cybister*, some species of which are common here (Lefroy, 1909).

The larva of the *Cybister* beetle (Porteir, 1911-12; Mukerji, 1929, 1930*a*, 1932*a*) is aquatic in habit and is a good swimmer, but towards the close of its larval life, it creeps to the land for pupation although its legs are ill-adapted for progression on land. There are ten pairs of spiracles distributed over the trunk, but not on the head. All these except the last pair are situated on the sides of the body, the first pair being mesothoracic in position. The last pair is peculiar in being placed on the extremity of the narrow pointed end of the abdomen. This pair functions both in inhaling and exhaling air.

The larva generally keeps near the surface of water resting on submerged weeds. It respires while under water, by raising the tip of the abdomen carrying the last pair of spiracles, above the surface of the water. If a living larva is placed in a beaker of water, and the level of the water is gradually raised the curvature of the abdomen of the insect will be found straightening out so as to put the terminal spiracles above the surface till the body stands vertically down. It holds on to this inverted position even when walking through a shallow water. Miall (1891) remarks that the position of the respiratory organ at the tail end and of the mouth at the opposite end, is of obvious advantage to the aquatic insect in feeding and breathing at the same time. Sometimes, however, it makes periodic excursions deep down under water in search of prey. It hunts shrimps, insect larvae and small fishes, and is particularly fond of attacking goldfish in an aquarium. As it bites, a thick brownish fluid flows out of its sickle-shaped mandibles, into the body of its prey and dissolves there the soft parts of the body. The tissues thus liquefied are then sucked in. This mode of feeding by extra-cellular digestion takes some time, and if the victim's body sinks under water, it sticks to it till the meal is complete.

Hence it is important to ascertain how long it can remain under water without seeking fresh atmospheric air. I have found by drowning experiments which were made by not allowing the specimens to come to the surface of water for taking fresh air, that the larva can safely remain completely immersed in water for a period of 30 minutes at least, and can live without fresh air for nearly four hours, although it usually makes efforts to get to the surface of water after 6 to 12 minutes. It will be interesting, therefore, to know, firstly, whether it is oxygen deficiency or excess of CO_2 that makes it come near the surface of water for the purpose of breathing, and secondly what is the total capacity of the trachea for holding the respiratory air. Krogh (1920) mentions that in the case of the *Dytiscus* larva which resembles the *Cybister* species in habit and structure, the ascent to the water surface is due to the oxygen deficiency and not to an excess of CO_2, though Stahn (1928) is of the opinion that in the ordinary life of insects, CO_2 is the more important factor in regulating respiration. The latter view apparently finds support from the experiments of Wrede and Kramer (1926) on *Naucoris* which remained at the bottom and expired when the water in which it was kept was exposed to oxygen. Wigglesworth (1931) remarks that the apparent toxic effect of oxygen was due to the fact that there was no oxygen want to stimulate the insect to ascend to the water surface until all its air-store was used up and water had entered the tracheal system. As to the air carrying capacity of the tracheal system, according to Krogh's estimation in the case of *Dytiscus*, it amounts to 6–10% of the total volume of the animal, and the vital capacity is nearly one-third of the total capacity. During strong expiration the tracheal system empties nearly two-third of its total capacity of respiratory air. It may be remarked in this connection, that during vigorous swimming activity of the *Cybister* larva, bubbles of air were seen coming out of the mesothoracic as well as from the last abdominal spiracles (Mukerji, 1930*a*). Small vesicles of air were also found adhering to the outer surface of the remaining abdominal spiracles. These bubbles represent expired air, rich in CO_2. This finds support from Hazelhoff's (1927) view that concentration of CO_2 causes the opening of the spiracles. However, Demoll (1927) explains the streaming of air through the spiracles as a necessity for the ventilation of the large tracheal trunks.

The large tracheal trunks are alternately constricted and dilated along their length, and are capacious enough for storing a large volume of respiratory air. They are connected with one another by cross branches, and each trunk is joined to the spiracles of the corresponding side by lateral tracheal branches. From each trunk also arise a number of tracheal tubes, which subdivide themselves supplying various organs. One of the remarkable features of the large tracheal trunks is their elliptic cross-section. This peculiar shape of the large tracheal trunks is regarded as an adaptation to the aquatic mode of life, and according to Krogh (1920), has been influenced by the respiratory movements of the body. Since the large tracheae are devoid of any musculature of their own, filling in, or emptying out, of air through the spiracles, is possible only by the alteration of the tracheal dimension by the rhythmic movements of the body wall effected through the action of the muscles of the trunk region. The respiratory movements are controlled by the nerve centres in the thorax, and the respiratory centres are stimulated by environmental factors such as the P-h of water (Wigglesworth, 1931). While the inspiratory or expiratory currents of air, can be explained by the pressure of gases within the tracheal trunks, generated either by the indirect change in volume of the trunks, or by diffusion of gases, such pressure is not sufficient to account for the driving of air into the tracheoles having narrow capillary bore. According to Wigglesworth (1931), the passage of oxygen through the tracheoles, is effected by the osmotic pressure of tissuefluids the level of the column of which rises and falls within the capillary of the tracheoles, according to the variation in the osmotic tension of the tissuefluids.

Since the spiracles play the important part in the inspiration and expiration of the respiratory air, their structure deserves special consideration. It may be noted that Porteir (1911) considered all the spiracles except the last terminal, as closed and nonfunctional in the larva, and so he disregarded the structure of the lateral spiracles. These are found morphologically open, and have been studied in the *Cybister* larva for the first time by the author (Mukerji, 1930*a*). All the lateral spiracles except the second pair which is metathoracic in position, resemble one another in structure. Each of these spiracles is divisible into an outer and an inner chamber. The outer chamber opens to the exterior by a small funnel-shaped aperture. Its wall on all sides is rigid, and the internal surface is beset with stiff hairs which are directed toward the outer end. Their main purpose is to prevent entry of any foreign object into the spiracles as otherwise the passage will be blocked. The inner chamber is devoid of any hair. One of its side walls is rigid like that of the outer chamber, while its opposite wall is membranous and flexible. The flexible side wall contains inside it, incomplete bands of taenidia, which differ from those encircling the lumen of a trachea, in not being spirally coiled. The inner chamber towards the inner end, narrows down, by a kink, to pass into the tracheal branch which connects it with the tracheal trunk. The diameter of the connecting trachea is smaller than that of the inner chamber or that of the tracheal trunk.

The junction of the inner and the outer chamber is encircled by the closing apparatus. The closing-apparatus consists of a semicircular chitinous bow or arc. A thin plate, called the closing-fold, is attached on the inner surface, to the middle of the arc. The free end of the plate projects within the cavity of the outer-chamber of the spiracle. The two ends of the bow are connected in the fashion of a bow string by a separate chitinous plate called the closing-band, which slants up and projects into the cavity of the upper chamber. The middle of the closing-band is pressed from the outside, by the apical end of a chitinous lever which follows like an arrow, a radical direction. The handle of the lever is expanded into an L-shaped block. The end of this block is attached to one end of the bow. The opposite side of the handle of the lever is connected by long muscle fibres with the other end of the bow. As these muscles contract, the lever being pressed inward like an arrow, forces in the closing-band against the fold standing on the opposite side. The bow also bends in the middle narrowing down its inner lumen. The communicating passage between the inner and the outer chamber becomes effectively closed thereby. When the muscles relax, the opposing plates spring back again to the original positions, the lever being pushed out by the elasticity of the bow. The spiracle is now functionally open. The whole apparatus thus acts like valves for opening and shutting the spiracle. The musculature on the lever is placed on the flexible side of the inner chamber; since the muscle fibres pass across from the end of the bow to the handle of the lever, they partially surround the upper portion of the flexible wall of the inner chamber. The flexible wall of the inner chamber therefore moves in and out along with the closure movement, converting thereby the inner chamber into a small pump. Since when the insect is under water, the respiratory air is expelled and not drawn in through the mesothoracic spiracle, the little pump may be assumed to be exerting expulsion force, a backward current from passing inside into the trachea being prevented by the high internal pressure of the gases contained within the tracheal trunks and their branches. It is inferred that the pumping chamber contracts, before the closure of the valves in front, has been made. By the time the valves have been completely closed, dilatation of the pumping chamber follows, and the latter is filled with the expiratory current from the tracheal trunk. The expulsion force exerted by the pump, in addition to the tracheal air pressure, is needed to overcome the weight of the superincumbent column of water on the spiracular gases, as the insect dives down under water.

The second pair of spiracles which are metathoracic in position, differs from the remaining series in having membranous walls, which by apposition obliterate the passage between the aperture of this spiracle and the tracheal trunk. It is not provided with any closing-apparatus, or any taenidia which would render walls elastic and non-collapsible. It is also not lined by any hairs. It is nonfunctional in the larva. It may be looked upon as the precursor of air-sacs which develop in the winged adult.

The last pair of spiracles placed at the terminal end of the abdomen, is the most important for respiring atmospheric air when the larva leads an aquatic mode of life. This is raised above the surface of water when the rest of the body remains under water, as pointed out before. It differs in structure and function from all other spiracles of the body. This spiracle is very long as compared to others, and is directly continuous with the large tracheal trunk that runs parallel to the longitudinal axis of the body. The junction of the longitudinal tracheal trunk and the terminal spiracle of the same side is marked by a closing apparatus that is built on a different plan from the rest. The junction is far removed from the external apertures of the spiracle situated at the tip of the tail. The two external apertures of the last pair of spiracles are very close to each other, and are overhung by a pair of short chitinous plates which guard the outer ends of the spiracular apertures like lids or valves: when drawn together in the middle, the valves expose the apertures, and when spread over on the sides, they close the apertures. The sides of the pointed end of the abdomen carrying the last spiracles are fringed with long hairs.

The most remarkable structural peculiarity of the last spiracle is the course of the taenidia in it. The taenidia here interlace with one another forming a spongy tissue that is a characteristic feature of the spiracles of the aquatic insects in general (Portier). Moreover, there are no hairs inside this spiracle: no such strainer is required while breathing above the surface of the water with the outlet guarded by lids. Such a type of spiracle, as the last one, will be found useless, however, for breathing while the larva walks or rests on land, because dust particles are likely to pass inside it choking the air passage. On land, or in air, the type of spiracle found on the sides of the body, such as the mesothoracic one, is more suitable being short and provided with hairs which can act as strainers.

The closing apparatus here consists of two chitinous arcs or bows of different sizes, one placed within the other, with a space in between the two for the passage of air. The convexity of both the arcs is turned in the same direction, and the end of one is fixed to the corresponding end of the other. A band of muscles passes like the bow string from one end of the bow to the other. As the muscle-band contracts, both the bows bend in the middle, but the inner one, being more pliable, bends more, and so becomes applied against the other as to shut the space between the two.

It is worth while testing the conclusions arrived at from our structural study, by simple experimentation (Mukerji, 1930*a*). The last pair of abdominal spiracles at the tip of the tail end, was, therefore, sealed air-tight, and the larva was placed in water. The larva died indicating that although the mesothoracic spiracle is open to the exterior, it is useless for respiration under water. If, on the other hand, the larva with its terminal spiracles sealed be placed on land, it lives at least for two days after which it dies of starvation. This shows that the mesothoracic spiracle is suitable for respiration when the larva migrates to land for pupation. In the mature larva, all the lateral spiracles remain open to the exterior, while in the early stage, only the first pair remains open for liberation of excess of CO_2, and the remaining lateral spiracles, though morphologically open, are nonfunctional. Again if the mesothoracic spiracles as well as the other lateral spiracles are sealed air-tight, and the larva only with the terminal spiracles open, is transferred to land, or is kept in water, it lives without any sign of asphyxiation. This experiment shows the importance of the last abdominal spiracle for respiration during the larval life.

The mesothoracic spiracle has, however, its own use. It not only helps in the ventilation of the tracheal trunks by eliminating the excess of CO_2, but is also the organ of sound-production in the larva. If the larva be seized or teased, it throws its body into a strong lateral flexion, and a sharp squeaking noise follows, accompanied by a current of air streaming out of one of the mesothoracic spiracles. The sound production is defensive in action, its object being to frighten its enemies. This flexion of the body is quite different from the respiratory movements. It is presumed that by the sudden bending of the body, pressure is brought to bear on the respiratory air in the tracheal trunks, and the strong air current in streaming out through the spiracle either strikes against the sharp edge of the plates of the closing apparatus, or sets the plates into vibration, the column of air in the inner chamber of the spiracle acting as a resonator.

A question, however, may be raised as to why sound production is limited to the mesothoracic spiracle, while the other lateral spiracles are similar to it, in structure. The anatomical relation of the mesothoracic spiracle explains it. This spiracle is connected with the large tracheal trunk by an undivided tracheal branch, while the spiracles following it, are connected with the same trunk by a branch which is subdivided into three branches. Naturally an air current sent from the tracheal trunk, in the case of these spiracles, passes into three different directions, and the stream reaching a spiracle is too feeble for sound production. Secondly the air current in the tracheal trunk as it is forced in the forward direction by the flexion of the body, meets with the resistance offered by the long and slender tracheal branches anteriorly passing into the head; therefore this air current on reaching the level of the mesothorax is diverted into the mesothoracic spiracle. No sound is produced when bubbles of air slowly issue out of the mesothoracic spiracles during the swimming activity, because while the air comes out, it does not stream out in such cases with a sufficient force. The issuing of air bubbles from the mesothoracic spiracle also may be taken as an indication of the forward flow of the respiratory air currents within the tracheal trunks during muscular activity. The absence of any vibratory valves in the terminal spiracles precludes any possibility of sound production on their part.

Since the example, referred to above, is an aquatic species, an instance or two may be added from the terrestrial types.

The Bruchid or pulse beetles are well-known pests of the stored seeds of Leguminosae plants. They lay eggs on the outer coating of the seeds. On hatching, the larva bores into the seed and grows within the excavation it makes in the interior of the seed by devouring the cotyledonous portion. Except for the exceedingly narrow and tortuous passage made by the larva at the early stage in boring its way from the egg-shell into the seed, the cavity made within the seed has no communication with the exterior; there is no other outlet for supply of fresh air from outside, till a later stage of the larva is reached. Powdery shavings from the seed and frass accumulate within the hollow as it is being enlarged by the growing larva. It will be interesting, therefore, to know the respiratory system of the mature larva occupying the hollow, before it has cut a circular disc in the shell for the emergence of the imago.

The tracheal system is well developed and there are nine pairs of spiracles in the larva of *Bruchus quadrimaculatus* Fabr. (Mukerji, 1938). The most notable peculiarity is the existence of four pairs of large oval-shaped air-bladders which are connected with the tracheal trunks. These were first reported by Zacher (1930) in *Zabrotes subfasciatus* Boh. They differ from air-sacs in having thick walls strengthened by taenidia, and are comparable to tracheal dilatations. Evidently they store a large quantity of respiratory air and may serve as ventilating chambers of the tracheal system. But their exact significance is not known. However, they may be regarded as adaptive organs to meet the special requirements of respiration in a closed cavity of the seed.

The most remarkable results can be expected from a study of termites (or white ants), which are well-known for their social habits, though showing orthopteran affinities in structure. The winged forms on attaining sexual maturity leave the parent home and take to swarming in air. The winged females accompanied by winged males, alight and cast off their wings, and become the centre of a new colony founded under moist earth (Hegh, 1922). The deälated or wingless female grows to a voluminous size, by the enlargement of her abdomen followed by morphological changes and growth of internal organs. It is now known as the physogastric queen. The post-adult growth (Snyder, 1935) after sexual maturity, leading to physogastry, and the adaptive change from aërial to hypogaeic or cryptobiotic life in continuation of the sexual phase, are remarkable phenomena, particularly as no moulting intervenes between the growth periods.

Holmgren (1909) explains the physogastry of the queen on the basis of nutrition and exudation. Could there be any change as well in the respiratory system, owing to a change in the composition of blood initiated by a difference in the mode of nutrition, as the activity of the winged life which requires rapid oxidation of tissues slows down after deälation to a passive life under moist earth ?

I have observed that a large number of workers and soldiers congregate round the spiracular apertures of the queen of *Termes redemanni* Wasm., and lick a brownish granular substance exuded through her abdominal spiracles. The floor of each abdominal spiracle is perforated by a number of apertures, each of which leads into tracheal-like tubes. The secretory granules can be seen around the spiracles; such deposits also occur within the tracheal-like tubes toward their external openings. The passage of the secretion or exudation which is elaborated within the body by the special exudate glands described by Holmgren, has not so far been clearly explained (Bugnion, 1912), and I make a tentative suggestion that the tracheal-like tubes, opening on the spiraclés, are ducts of the inner exudate glands. The abundance of tracheae observable in the mature alate phase of the female, is not found in the physogastric queen: the tracheal branches are fairly distributed over the ovarioles of the sexually mature winged forms, but not a trace of them could be noticed within the multitude of ovarioles of the physogastric queen. Have the tracheae suffered here disintegration or turned into a new use, conditioned by the change in ratio of surface to volume ?

It may be noted that Collembola, some of which are termitophile, live in an atmosphere saturated with humidity, and have no tracheae or any specialized respiratory system at all. There are also increasing evidences of diffusion of gases through the integument, and a closer correlation between respiration and circulation by reports of oxygen carrying substances in blood of insects (Keilin, 1925; Muttoski, 1921). Welch (1927) remarks that may it not be that the internal events in insects, re concerned in the physical changes in the haemolymph which Ackerman (1926) showed has four kinds of lipoid globules and has great bearing on the development of organs in Aphids.

The Ventral Tube of Collembola

The Collembola (or spring-tails) have a long hollow cylindrical tube filled with blood and attached to the ventral surface of the first abdominal segment. This tube, called the ventral tube, ends in a pair of fleshy lobes. The tube was considered by earlier authors to be respiratory in function (Hoffmann, 1904). It has been an enigmatical organ, not being found in any other group of insects. It has given rise to numerous discussions. Almost all conceivable functions such as respiration, moistening, adhesion, lubrication, support and reproduction, have been ascribed to it (Mukerji, 1932*b*). However, the consensus of opinion has been in favour of regarding it as an adhesive organ, but the manner in which it could act was not established beyond dispute. Further, the existence of glandular elements in it was doubtful. To add to the confusion, we find a narrow groove running on the ventral surface of the body connecting the base of the ventral tube with the mouth. It was thought by some, therefore, that the fluid secretion of the glands present in the head region, while flowing out by the mouth, passed through the connecting groove to the ventral tube, which thus being smeared with that secretion acted as an adhesive organ (Willem, 1900 ; Hoffmann, 1904 ; Denis, 1928). The set of glands in the head, which supplied the sticky fluid to the ventral tube, was called, therefore, the cephalic glands of the ventral tube (Denis, 1928).

The author (Mukerji, 1932*b*) observed in a Collembola, *Protanura carpenteri* Mukerji, that the lobes of the ventral tube while they were pressed against the smooth surface of the object over which it walked, exuded little drops of fluid, by means of which the minute insect stuck to the smooth surface. The glandular nature of the ventral tube was confirmed by histological examination.

It was also noted that in living specimens, a viscous drop of fluid collected near the mouth, and the tip of the fore legs was bent forward and was smeared with this fluid. This process was repeated with the middle pair of legs. Generally when these minute wingless insects walk over a smooth surface like the plate glass, and their legs slip, the latter are smeared with the fluid gathered outside the mouth-cavity, thus enabling them to move forward, or hang on. The species *carpenteri* is found in moist earth under decaying vegetable leaves. It also lives under the smooth and polished leaf-stem of plantain trees. This mode of life necessitates some form of adhesive apparatus.

On examining the anatomical relationship of the various glands present in the head region, I found that the secretions with which the tips of the legs were smeared, came from tubular glands, that opened by a pore, placed a little posterior to the mouth aperture.

My observations thus support the view put forth by Folsom (1899) but discredited by the later authors, that the secretions elaborated by the tubular glands of the head, pass to the mouth, and are not conducted through the ventral groove to the ventral tube.

The tubular glands in my species, consists of a sac, a labyrinth and a duct. They are homologous with the excretory glands of the Crustacea. The ventral tube, therefore, is an adhesive organ by itself, and has got nothing to do with respiration which is carried on by the entire surface of the moist body.

Reproductive System

Reproduction is necessary for the perpetuation of the species. The reproductive system of insects has been elaborately studied from the point of view of development and phylogeny (Weber, 1933). The physiological aspect of it, however, can be approached, either from the standpoint of a geneticist, or from that of the Lamarckian school of thought.

The importance of isolation as a factor of organic evolution stands undisputed, though the interpretation of its rôle is fast changing (Dobzhansky, 1937). The physiological isolation in preventing interbreeding of species does not let in any chance of the breaking down of harmoniously balanced constellation of genes that was established by the slow and gradual process of natural selection. Interbreeding would bring in, new, or a recombination of genes, resulting in dissolution, and swamping of the differences by crossing, or production of unfit, or still less, new forms. If the differences between the individuals and the group be due to a single gene or a single chromosome, segregation of characters would take place resulting in the reappearance of ancestral traits in the offspring.

One of the mechanisms for the maintenance of physiological or sexual isolation, is provided by the difference in the genitalia of different species of insects. Closely related species which are difficult of separation due to the variability of the external morphological characters, can be distinguished by the structure of their genitalia. Further, the female genitalia of a species is regarded as the negative replica of the male of the same species, owing to the existence of specific differences in the female genitalia corresponding to the characters of the male. This is known as the 'lock-and-key' theory which means that every lock has its own key and can only be opened by the same.

The lock-and-key arrangement in the genitalia of a couple belonging to a certain species, mechanically prevents that species from interbreeding with closely allied species, that may share with them the same environment. This holds true in certain species of Lepidoptera. The effectiveness of this mechanical form of isolation, however, has been questioned (Dobzhansky, 1937), other factors such as the ecological ones, the chain of internal reactions controlling fertilization, the viability of eggs and sterility, being regarded as more operative in the maintenance of sexual isolation than the 'lock-and-key' theory suggests.

If members of any two species of insects, which differ in their genital structure, pair with each other, lay viable eggs, but if no fertile offspring is born of the hybrids, neither the one view, nor the other, is proved, nor disproved thereby. More facts about successful crossing of related species, which under normal conditions differ in the genitalia in both the sexes, are needed for determining the question definitely, one way or the other.

In evaluating the relative importance of the various factors involved, a knowledge of the structural details of the reproductive organs and how they operate in the course of sexual union, is essential.

The writer (Mukerji and Bhuya, 1937) investigated the reproductive system of both the sexes of two species of Bruchid beetles which were found in Calcutta along with other species infesting stored grams and pulses. The genitalia of a couple was studied while they had been joined in action and after their disengagement. The two species *Bruchus quadrimaculatus* Fabr., and *Bruchus* (*Callosobruchus*) *chinensis* L., differed from each other markedly by the character of their antenna, their size and colour; but they were observed by us interbreeding, if the males of the one species were kept with the females of the other, in a separate vial, isolated from other individuals. Viable eggs were laid, and the first filial generation could be raised and bred under laboratory conditions. The hybrid generation generally resembles the female parent. Segregation takes place in the next generation. If, however, the members of one species have access to members of the opposite sex of the same species, inbreeding follows, and no interbreeding takes place even among the mixed lot of the two species containing both the sexes. The hybridizing experiment referred to requires repetition and corroboration.

The two species differ from each other markedly in the structure of their genital organs in both the sexes, as well as from other species described by Zacher (1930, '31).

In *B. quadrimaculatus* the testes are spherical in shape and occur in two pairs. The vas deferens, soon after its origin, dilates to form the vesicula seminalis. A common duct carries the products of the genital glands as well as those of accessory glands, and opens into the ejaculatory duct. The latter also receives the secretion from the prostate. The ejaculatory duct passes through the muscular bulb which is equivalent to the phallobase of Snodgrass (1935), and opens on the internal sac called the preputial sac or vesica by Snodgrass. The intromittent organ is composed of the phallosome and the internal sac. Both these parts are the terminal and eversible portion of the aedeagus and lie retracted within the middle portion of the aedeagus called the phallic capsule, the basal portion being formed by the bulb. In repose, the phallic capsule with the terminal portions of the aedeagus folded within it, lies drawn within the genital atrium (or the genital chamber of Snodgrass); during action this is pushed out to the exterior while the parts, ensheathed within it and the bulb, are shot out. The phallic capsule carries at its posterior terminal end, a curved hook which is provided with a tuft of long sensory filaments.

The phallic capsule, together with the phallosome, corresponds to the endophallic tube of Snodgrass. When these eversible parts are fully protracted, the aedeagus forms a long tube, outside the body, but the basal portion of it, namely, the muscular bulb, while it slides down through the genital atrium as far as the external genital aperture, it is never exposed to the exterior.

While the phallosome and the internal sac are inserted within the genital pouch of the female, the phallic capsule remains outside the generative aperture of the female, but the hook at its terminal end is pressed against the external zone of the genital aperture of the female to act as a tittilator. The phallic capsule is the supporting organ, and its wall is hard and rigid owing to strong chitinization. The phallosome is provided with spines which interlock with narrow crypts of the genital pouch of the female. It is remarkable that in this species, the membranous internal sac is never everted till the phallosome is introduced into the genital pouch of the female. The phallosome or the internal sac even when fully everted, neither reaches at the time of sexual union the anterior extremity of the genital pouch of the female, nor does the external opening of the internal sac come into juxtaposition with the opening of the spermathecal duct of the female.

The parameres attached to the muscular bulb run parallel to the two sides of the phallic capsule. The terminal or apical end of the paramere is truncated and provided with sensory setae. The males palpate the external genital aperture of the female by the apical end of the parameres which are, however, kept outside the body of the female.

In *B.* (*Callosobruchus*) *chinensis*, the reproductive system is of a slender type. The efferent system differs from that of *B. quadrimaculatus* in the disposition of the accessory glands. The phallosome contains minute setae and not the large dagger-shaped spines characteristic of *B. quadrimaculatus.* The external surface of the internal sac is covered with denticles and carries a pair of chitinous discs bearing hooks. These armatures are absent in the other species. Further, in the species *chinensis,* the internal sac is drawn out in the region of its apical aperture, into a narrow lobe. The sac is everted before the intromittent organ is introduced within the body of the female, while at the time of the sexual union, unlike the corresponding organ of the other species, reaches the extreme limit of the genital pouch of the female. The parameres of the *chinensis* species are distinguished from those of the other by having a spiny protuberance at the apical region.

With regard to the female genital system, both the species have the same number of ovarioles, and the same type of ovipositor, due to the similarity in habit. They differ from each other in the structure of the genital (or copulatory) pouch.

In *B. quadrimaculatus* the pouch is divisible into three portions, and the upper portion of this is distended into a thin spherical sac forming the bursa. The male intromittent organ, however, does not penetrate into the bursa being prevented by a pair of valves situated near its junction with the middle portion of the pouch. The bursa, after the sexual union, is filled with the secretions of the accessory glands of the male. The middle portion of the pouch has a thick wall and is lined by a well-developed chitinous intima; it receives the intromittent organ, namely, the internal sac and the phallosome, the spines of which interlock with the crypts of the female pouch. The pouch receives the spermathecal duct as well as the oviduct—the openings of the two being widely apart. The spermatheca is curved and is provided with a long accessory gland. Immediately after pairing and even before the intromittent organ is withdrawn, the spermatozoa pass into the spermatheca of the female and remain stored there. During the descent of eggs into the pouch, some of the stored spermatozoa are carried back into the pouch by a stream of liquid secretion discharged by the accessory gland of the spermatheca. The lower division of the pouch serves as the fertilizing chamber.

In *B. chinensis* the genital pouch, corresponding to the shape of the male genitalia, is more elongated and narrower than that of the other species. It is not divisible into three distinct portions; it lacks the bursa as well as the valves found in *B. quadrimaculatus*. The pouch receives the intromittent organ; its lining intima is thin as compared to that of the other species, and in conformity with the finer setae of the intromittent organ of its male. The spermatheca is U-shaped and the accessory gland attached to it is short.

Both the species are polygamous in habit. Frequent matings occur among individuals of the opposite sex belonging to the same species (Mukerji and Bhuya, 1937*b*). Males are aggressive and females play a passive rôle. A single male may successfully mate with as many as five different females, and the same may be said of the other sex. The sexual union may last as long as three minutes, and the females usually try to disengage themselves and may be overturned, but the interlocking arrangement is too strong for them and the long aedeagus a portion of which is lodged within the female, gives a sufficient play for the movements. Egg-laying starts within twelve hours of the first mating and continues at intervals, during which fresh matings take place. In *B. quadrimaculatus*, nearly 80% of the eggs are viable, and the proportion of male and female offspring is nearly equal.

The structure of the genitalia, in spite of the specific differences, seems to me, not an effective bar against the interbreeding of the species, and the physiological isolation, in the absence of individuals of the opposite sex of the same species, disappears by force of circumstances. This raises the important question whether we are not having hybrids among the so-called distinct species of the Bruchid beetles infesting our stored products. A genetic analysis of the various species and the examination of their genitalia are needed for the purpose.

I may conclude with the observation made by Snodgrass (1935), 'The morphologist, therefore, though primarily a comparative anatomist, in order properly to develop his subject, must give attention to the working of the physical mechanisms with which he deals in his anatomical studies, he must look for the significance of structural modifications and innovations and he must understand the basic physiological functions that underlie organic form'.

Finally, I desire to acknowledge my sincere thanks to my learned colleagues for their kind co-operation and for the great honour they have done to me as well as to my learned audience for the patient hearing given to me. Our best thanks are also due to the local officers of the Science Congress for their kind courtesy and gracious hospitality.

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SECTION OF ANTHROPOLOGY

President :—M. H. KRISHNA, M.A., D.LIT. (LOND.)

Presidential Address

(Delivered on Jan. 3, 1942)

PREHISTORIC DAKHAN

CONTENTS

INTRODUCTION

I am highly thankful to the authorities of the Indian Science Congress and particularly to the members of the Anthropology section for electing me to the Presidentship of this section. When it was proposed at the Silver Jubilee Session that the archaeologists should be given greater opportunities of associating themselves with the study of anthropology in the Congress and when our much respected friend and colleague, the Director-General of Archaeology, was elected to this office at the Madras session, I did not realize that my opportunity would also come so early. I believe this kindness has been bestowed upon me because the Congress feels an increased interest in the problems of Indian Prehistory which some of us are trying to understand with a view to their future solution.

The rapid strides made by the progress of Prehistoric Archaeology elsewhere in the world and particularly in Europe have been surprising and highly interesting. The old belief that mankind was created about forty generations before Jesus Christ or some three thousand years ago and that human culture developed in a few generations into what it was among the Hebrews and the Greeks has given place to a long account of the evolution of man from the ape to the modern races. The development of human culture in western Europe through the numerous paleolithic, neolithic and metal age stages has now become an accepted fact both of science and of history. In fact history now begins with the story of man's evolution and his early culture.

Importance of Indian Prehistory.—Outside Europe too, here and there and particularly in Africa, prehistoric investigation has been carried on and compared with the results obtained in Europe. In India after a few preliminary observations by Logan and others, Bruce Foote took up the study in right earnest and made a magnificent contribution to the subject. His work on Indian Prehistoric and Proto-historic Antiquities published by the Madras Government Museum in 1916 is yet the basis on which further investigation has to proceed. Dr. Panchanan Mitra's Prehistoric India is a work containing valuable facts and numerous highly valuable suggestions. But his unfortunate early demise has prevented the scientific world from having the benefit of getting his matured conclusions. Professor Rangacharya's work on Prehistoric India has made a careful and painstaking effort at putting together the known information on the subject from the ethnological and cultural points of view. But in the field of original exploration and investigation the greatest revelation has come from the discovery of the Indus Valley Civilization of the Copper Age in India. This has now opened up a new vista and encouraged the fieldman to address himself to the task of discovering more facts about Prehistoric India.

Races of India

The Coming of the Races.—The historian of India now acknowledges that three of the greatest historical facts occurred long before the history of India as now known to us dawned, namely: the coming of its great races, the coming of its great languages and the growth of its great cultures. It is now an admitted fact that though people of different races have immigrated into India during the historical period covering the last three thousand years, the ancestors of the great mass of the Indian people came to this country in the prehistoric times. The greater part of the racial history of India belongs to prehistory. This subject is one of primary importance to the Indian prehistorian. But owing to inadequate progress in prehistoric field work, the present position of this subject has to depend very much on inferences based on an analysis of the existing races of India.

Races of India.—On the subject of analyzing the existing races of India considerable progress has been made though the final word has not yet been said. In my Presidential Address to the Anthropology section of the Tenth All-India Oriental Conference I have tried to review the contributions of the chief authorities on the subject and to give my own suggestions thereon. I have shown how the conclusions published by Sir Herbert Risley in his pioneer book on the People of India, though yet forming the foundation of all subsequent investigations, have had to be considerably modified in the light of the progress made by Physical Anthropology in the western world. After reviewing the contributions of several scholars, I have tried to put together the results of the investigations of Baron Eickstedt, Dr. B. S. Guha and others. I have suggested an analysis which we may accept as a basis for more detailed study in the future. I have preferred to retain commonly the familiar termination *ic* to Eickstedt's *id* which is also acceptable. The analysis given by me is as follows:—

A. MAJOR RACES:

I. Indo-Europic race—This consists of the great bulk of the people of India. Its branches have been settled in India from prehistoric times. Four branches are distinguishable:—

(1) Indic—Eickstedt's Indid, Guha's Basic Dolicocephalic and Risley's Aryo-Dravidian. It is the largest single sub-race in India. It is a distinct branch on the Brown section of the so-called Caucasian or Indo-European race, and inhabits large parts of North India and South India.

(2) South-Indic—Eickstedt thinks that the Melanid type of the lowest Tamil castes has arisen owing to an ancient admixture with the Malic hill type. Risley describes it as Dravidian. Guha does not give it an independent place. For purposes of discussion it may be called South-Indic.

(3) North-Indic—Eickstedt's North-Indid, Guha's Indus, Risley's Indo-Aryan. It is a branch of the brown race with more refined features than No. 1, fairer and taller. It is found commonly in North-West India, but is spread over the rest of India, particularly in the higher castes.

(4) Brachic—Eickstedt's Brachid, Guha's Alpo-Dinaric and Risley's Scythio-Dravidian and Mongolo-Dravidian. These are round-headed brown people occupying Western India and Eastern India.

B. MINOR RACES :

II. Indo-Europic—Small groups coming in more recent times.

(5) Indo-Nordics—long headed, fair haired and fair eyed (Red Kaffirs).
(6) Orientalic—Round headed, long nosed, black haired.

III. Proto-Australic—very small numbers.

(7) Gondic—Central India.
(8) Malic—South Indian hills.
(9) Veddic—Ceylon.

IV. Negric—very small proportion.

(10) Negritic—Andamans, etc.
(11) Melanesic—Assam Nagas, etc.

V. Mongolic—small numbers mostly on the borders.

(12) Paleo-mongolic—Central Indian tribes.
(13) Tibetic.
(14) Assamic.
(15) Burmic.
(16) Oceanic.

Racial History

Racial History.—On the basis of this racial analysis and of the general racial history of the world corroborated by a few stray facts discovered in India, the racial history of the country has had to be built up. Naturally at this stage it cannot be anything more than a generally accepted hypothesis. It may be taken as a provisional scheme to be confirmed by future study particularly in the form of excavation of prehistoric tombs.

Negritic.—The primitive features of the Negritos of the Andamans close to the mainland of India and the existence of a Negroid strain among the Panians, the Kadirs and other primitive folk of Malabar, microscopic though it be, suggests that ages ago a Negritic people with a very low stage of culture might have touched the Indian shores. It has been presumed that they were the earliest race of men to live in India.

Melanesian.—The discovery by Dr. Hutton and others of a Melanesian strain among the Nagas of Assam and some of the Chota Nagpur tribes has suggested an immigration into India from the south-east, of small colonies of pacific negroes. It may be supposed for the present that they were the second group of humans to enter our country.

Proto-Australics.—The next race, which was much more widespread than the first two, was the Proto-Australic with its Veddic and Gondic branches in the extreme south of India and in Central India respectively. The fact that the Veddas of Ceylon are yet in the hunting stage suggests that these Australic people also were in a very low stage of culture. Though this race is rarely found in its purity, a considerable strain of it has been noticed to exist throughout India and more especially among the lower classes of the Tamil country. Eickstedt supposes that its admixture with the Indic type took place very long ago resulting in a rather homogenous looking standard type found in the Tamil lower classes. But this admixture took place when the Indic people immigrated into the erstwhile Australic area and thus produced what has sometimes been considered to be a South-Indic type. The presence of a few ultra-dolicocephalic smallish skulls at Mohenjodaro points to the fact that the Proto-Australic race had once perhaps an all-Indian spread.

Indic Race.—Perhaps one of the largest immigrations into our country was the coming of the Indic race probably in the microlithic or early neolithic period. It appears to have come from its original homeland (in Central Asia ?) through the north-western passes possibly about ten or eight thousand years ago bringing with it its parental Dravidian speech. It occupied practically the whole of India, its lower orders mingling with the previously existing races where the latter were strong in numbers and adopting the immigrants' higher culture. Dr. Guha considers it the Basic Indian race. There is little doubt that it is a distinct branch of the Brown section of the so-called Indo-Europic race.

Brachic.—It is doubtful whether the next race to come into this country was the Brachic one represented by the West Indians and the Bengalis or the North-Indic race. From the position it occupies in the Central Indian belt stretching from west to east and the way it has become mixed up with the earlier races, I am inclined to think that the brachic element is the earlier. As Dr. Ghurye has suggested in his 'Caste and Race in India', it may have come through Baluchistan to Gujrat and Maharashtra and then spread out to the east in later times. It does not appear to have passed through the Punjab and Rajputana.

North Indic.—The last great race to immigrate into this country appears to be the one identified by Eickstedt as North-Indid which now inhabits the Punjab, Kashmir and Rajputana. Dr. Guha has shown that it is different from the Nordic race thus suggesting that it was only a tallish branch of the Brown race. That it was in the occupation of North-Western India long before the Aryans developed their Vedic culture (c. 1500 B.C.) is established by a study of the Mohenjodaro skulls. The race was mostly Pre-Aryan. The fact that this race is comparatively pure goes to suggest that if the Aryans came to India from elsewhere at all they were of almost the same race as the people they conquered.

Other Races.—The later immigrations of the Chalcolithic, the Nordic, the Oriental, the different varieties of Mongolic and other elements appear to have taken place in such small numbers that they have not seriously affected the racial characteristics of the population of India. It is interesting to notice that all the great races of India, whose descendants the vast majority of the people of this country are, came and settled down in the prehistoric times. History had not yet begun, even when some great internal migrations took place and the brachic element occupied Bengal and the North-Indic element spread through Central India and the Dakhan and sprinkled itself over the Nilgiris and the Tamil and Malayalam lands.

Coming of the Languages

Coming of the Languages.—Another important fact in the past life of the Indian people which also took place in the prehistoric times is the immigration into India of its languages and their original ancestors. Thanks to the Linguistic Survey of India and other studies, we know that the languages of India may be roughly grouped under the three heads: Austric, Dravidian and Indo-Aryan.

Austric.—Of these it is definite that no Austric-speaking people immigrated into our country during historical times. In all probability the original Austric languages came with the coming of the Proto-Australic people, for even now these languages are prevalent among some of the tribes which bear Australic racial features. Thus it is possible to imagine that the coming of the Austric languages may be traced back to the paleolithic times.

Dravidian.—The incoming of the Dravidian languages is also prehistoric. We may not be wrong if we guess that the parental Dravidian language was brought into India by the Indic race of people, who might have adopted it when they were in contact with some Central Asian people, speaking the agglutinative languages. Since the agglutinative stage may be one earlier than the infectional, it is not impossible that the Indo-Europic people spoke agglutinative languages in their Central Asian homelands ten or fifteen thousand years ago. However, it may be supposed that the Indic people brought the original Dravidian languages with them and continued to use them until a foreign speech, inflectional in character, was introduced either by the Brachics or by the North-Indics.

Indo-Aryan.—The problem of the Indo-Aryan languages has been well known. They appear to fall into two groups forming the outer ring and the inner ring. To explain this phenomenon some scholars have suggested that after the first Aryan immigration into India through the Khyber and other north-western passes, a second Aryan invasion entered the Gangetic plain through Chitral and the northern passes. If we leave aside the Punjab and the United Provinces we find that the outer ring of languages is generally spoken by the

Brachic people of India. Either these people might have brought the parent of the outer ring languages with them or they might have learnt the outer ring languages from their neighbours. We may suppose that they brought them until it is proved to the contrary. The problem of the original language of the Punjab and the United Provinces is too intricate for a discussion here. Fresh light could have been thrown upon it if the inscriptions on the Mohenjodaro seals had been read satisfactorily. The suggestion of Rev. Heras that the Mohenjodaro language is original Tamil and the suggestion of Dr. Waddel and others that it is akin to Vedic Sanskrit have not been received by the scholarly world with any show of approval. When I attempted a reading of some of the Indus valley inscriptions some years ago, I was also led to something akin to Vedic Sanskrit. But I gave up the attempt since it was pointed out to me that my method itself appeared to be fundamentally heterodox. Thus we are waiting helplessly for the occurrence of some bi-lingual inscription which only can throw definite light on the subject. However, we are justified in the conclusion that the parents of the present languages of India entered this country in the prehistoric times.

Prehistoric Cultures

Culture and Prehistory.—The developments that took place in the cultural history of our country in prehistoric times are at least as interesting and important as those relating to race and language. It is a pity that we are as yet unable to throw much light upon such cultural aspects of prehistory as cannot be dealt with by the geologist or the archaeologist. It has not yet been possible to make use of the many valuable ethnographic studies of the primitive tribes of India for a reconstruction of many aspects of cultural history. Many of the observations we make have necessarily to be confined to inferences made from material remains. To the account of Indian prehistory as given by Bruce Foote in 1916, the only great addition that has been made is the story of the Indus Valley Civilization. The survey of the prehistoric sites of India by Dr. Leonard Woolley was more in the way of making administrative suggestions than evaluating the scientific aspects of the sites. But the survey of stone-age sites made by the American Scientific Expedition in the north-west of India has revealed that there is a great field for investigation among the north-western mountains as well as in the Dakhan. A study of the prehistoric antiquities of Bihar and Chota Nagpur by the scholars of Calcutta and the attempt made by the late Mr. Karandikar to unravel the mysteries of the Narmada valley, the survey of South Indian sites recently made by Mr. V. D. Krishnaswamy, the discovery of prehistoric sites made by Prof. Dubrenil near Pondicherry and by Mr. Panchamukhi in the Bombay Karnatak, the study and excavation of the prehistoric sites of Hyderabad made by the Hyderabad Archaeological Department under the able guidance of Mr. Yazdani and similar investigation carried on in Mysore by the Mysore Archaeological Department are bringing to light interesting facts which need to be grouped together for study. I shall be glad if the Director-General of Archaeology can take up this task. I would be doing my humble service to this great investigation if I could place before the learned world the observations bearing on the subject made by me in the course of my study of the prehistory of the Dakhan and of the excavations conducted in the Mysore State.

Prehistoric Mysore.—In the course of my investigations I have found that in common with the antiquities of the rest of the Dakhan plateau, the prehistory of Mysore goes back to the lower paleolithic times. Evidences occur of cultures corresponding to the lower paleolithic, the microlithic, the early neolithic, the full neolithic and the iron ages before the commencement of history. The earliest historical event definitely known in Mysore is that a good part of it was in the occupation of the Mauryas possibly in the days of Bindusara and Asoka for a period extending from about 298 B.C. to 232 B.C. Anything before 300 B.C. thus belongs to prehistory in Mysore just as in the rest of the Dakhan.

Lower Paleolithic.—In the course of my survey of the ancient sites of Mysore, I have come across three stations which are definitely attributable to the lower paleolithic period. No definite eoliths have occurred till now. But among the chipped axe heads seen by me there are several which have a comparatively large belly and a few have the patinated original surface of the core still showing. I may be pardoned if I use for comparative study the terminology common in European prehistory. At Kibbanahalli in the Tiptur Taluk, at Talya in the Holalkere Taluk and at Lingadahalli in the south-east corner of the Bababudan hills, Chellean looking large bellied celts have been picked up. They occur mostly on the slopes of ridges and hills and have evidently been brought to light by rain water laying bare buried strata. Similar implements in France have been assigned to about 50,000 years ago. Occasionally we come across axe heads better chipped with thinner bellies and sharper. They may very well compare with the Acheulean implements which were in use more than 30,000 years ago in Europe. A careful search among the paleolithic fields brought to light the fact that the paleolithic Dakhani had occasionally used the flake instead of the core for producing a thinner and sharper implement. This gives us a parallel to Mousterian workmanship. As for traces of Aurignacian craftsmanship, it is highly doubtful if the characteristic retouch is present.

Upper Paleolithic.—So far as upper paleolithic sites are concerned, I have not yet found any traces in Mysore. It is a well-known fact that the Solutrean leaf flake and other characteristic tools have not till now been found in India and it has been assumed that India did not pass through any corresponding stage. Bruce Foote states that in the Billa Sargam caves of Kurnool, bone implements, characteristic of the Magdelanean period, were found. This is nothing impossible, for our geological friends have often come to the conclusion that India passed through her own glacial periods. However, I have no definite evidence to offer on this matter. The Mysore finds become more interesting when we investigate the existence of mesolithic and later cultures.

Chandravalli Excavations

Prehistoric sites in Mysore.—From the neolithic period onward my remarks are based more or less on a direct study of prehistoric sites in Mysore. Within the confines of that State, I have noted nearly two dozen ancient sites the majority of which can by virtue of surface indications and other evidence be assigned to the periods of the historical dynasties which ruled the Mysore plateau. They extend in time from Tipu's Palace site at Seringapatam and the Mulbagal and the Chandragutti areas of Vijayanagar days, to the Hoysala palace and temple sites at Halebid and the sand covered Ganga capital at Talkad, back to the Chandravalli and Brahmagiri sites of the Satavahana and Maurya times and even to the earlier prehistoric iron age and neolithic periods. On this present occasion I shall confine my attention to only two prehistoric and proto-historic sites, namely, Chandravalli and Brahmagiri. These two sites are of special value because their upper layers can definitely be proved to be connected with the Satavahana and the Maurya times respectively, while their lower levels carry us through the iron age to the neolithic period and even to the microlithic period. They may very well be claimed to be the links between the historic and the prehistoric. The work done in either of these places has not been very extensive, but an earnest effort has been made to study the stratification and record the results correctly both by diagrams and photographs. Though the results should be subjected to verification both in the sites themselves and elsewhere, it may be claimed that they serve as provisional indexes to the sequence of prehistoric cultures in the Dakhan.

Chandravalli site.—Chitaldrug is the northern-most district town of the Mysore State adjoining Bellary. Immediately on the west side of its fortified hill lies the valley of Chandravalli now well known to Indian archaeologists. Since a few lead coins had been picked up in the valley and they had been identified by Dr. Rapson as belonging to the Satavahana epoch, Sir John Marshall suggested to the Mysore Government that the site might be systematically studied and excavated. After a preliminary study in 1908, the late Mr. R. Narasimhachar felt that the site was a promising one fit to be excavated. By the kindness of the Government of Mysore, I was able to spend a few very short seasons at the place; and, though only a small area has been excavated, we have been able to form an idea of the general contents of the site.

Overground Survey.—We commenced by making a careful overground survey and preparing a detailed map of the place before sinking any excavations into it. Even this survey convinced me that the site contained in it antiquities of many different ages extending from the nineteenth century to the neolithic times and including many layers of a long lived city of about two thousand years ago. By a careful analysis of the finds we formed a theory of the various strata that we should look out for in the course of the excavations.

The Excavations.—From the surface finds it could be gathered that the site consisted of a triangular valley bounded by three lines of hills and extending over more than one square mile. As my resources were exceedingly modest in men and money, I commenced testing operations by sinking more than forty trial pits in the different parts of the site. We were thus able to fix up the central area. Here again we sank a few pits more and connected them by trenches. These trial excavations mostly confirmed the theory we had formed about the stratification and also led to some important modifications. Finally, we selected a definite area in the central place, excavated it and made a systematic study of the finds as they turned up. The result has been the collection of more than six thousand objects, large and small, with records of their occurrence both by plan and by section and also by association and with numerous diagrams and photographs.

Study of the finds.—I believe a word of explanation is due from me to students of archaeology all the world over since there has been considerable delay in the publication of the results of the Chandravalli excavation in detail. This delay has been primarily due to the fact that the special staff which helped me in conducting the excavations was abolished immediately after our return to the headquarter and I found it an extremely hard task to plough the lonely furrow in the midst of the other heavy duties I have had to discharge. Several of the packing cases lay unopened in the cellars of the Mysore Archaeological Office as there was no accommodation for opening them out and studying the finds. But since the man who quarrels with his tools naturally deserves to be considered a bad workman, I have done my best to spread out the finds and study them to the best of my ability. The result of this study may be stated very briefly as follows. Under each stratum, I make a reference to only the most important finds, describing summarily the historical strata, and more in detail the prehistoric ones.

Chalukya-Hoysala layer.—A few of the finds definitely belong to more or less recent times and they need not be mentioned here. In the excavations the first layer that we come across almost within nine inches of the surface, was the Chalukya-Hoysala layer corresponding to about the 12th century A.D. The relics of the period found were two temples, one standing and the other collapsed, with evidently Chalukyan potstone workmanship, a Chalukyan inscription of the 11th century A.D., bearing the name of Trailokyamalla Somesvara, the foundations only of a horse stable, a collapsed shrine showing a number of Virarayi hanas with the lion on the obverse and the virarekha on the reverse, and a therio-morphic potstone vase showing the traditional progenitor of the Hoysala family stabbing a lion with his dagger. Below this Chalukya-Hoysala level, there was evidence of a period of jungle life as seen from the teeth of a large carnivorous feline creature, possibly a tiger.

Proto-history.—I now arrive at the vestiges of an epoch in which prehistorians may take an interest. It may be dated about 300 B.C. to about 300 A.D. I would call this period the proto-history of the Dakhan since we know so little about the material culture of the times, and a study of its pottery and other antiquities must necessarily precede our study of prehistory. To our great luck, we found at Chandravalli inscriptions and coins which could more or less be definitely dated. Thanks to Dr. Rapson's great work on Andhra coins and other contributions to the subject, we were able at Chandravalli to identify at least three different layers as belonging to the Satavahana times, from the nature of the coins occurring therein. The end of the period appears to be marked by a Prakrit inscription engraved on a boulder across the gorge to the south of Chandravalli valley known as the Hulegondi gorge. The inscription which is in Brahmi characters and Prakrit language mentions that Mayurasarma, the Kadamba, who had defeated a number of the neighbouring states got a tank constructed at the place. Since Mayurasarma's date is approximately known as circa 340 A.D. we have a starting point from which we can go back in our study of the history of the town. Naturally, I have to mention the layers in the order in which they occurred, that is, the reverse of the chronological and from here I go on naming them as in our registers.

Satavahana Town.—Chandravalli town evidently extended in time from the 4th century A.D. back to the Maurya and Pre-Maurya times. Briefly its story appears to have been this: It began as a small village some centuries before the Maurya occupation of the neighbouring areas; and after a prehistoric life, it passed through the Maurya period growing in size and prosperity. It grew more important when the Satavahanas began to rule the neighbourhood and it rose to be the capital of a local state ruled over by several generations of Maharathis or semi-independent governors, who issued their own coins. The period of its greatest prosperity was in the 1st century A.D. when it must have been a manufacturing town, in exchange for whose products even Roman coins poured in as also coins from distant China. The great Satavahana Emperors, Gautamiputra Satakarni and Pulimavi, ruled it also. Somewhere about this time, kings of the Satavahana dynasty claiming descent, possibly on the maternal side, from the Chutus and the Mulas ruled the place. Subsequently there came a period when Yajnasri Satakarni brought the town under his sway. He and his successors ruled the place for some time until at last the kingdom passed into the hands of Mayurasarma, the founder of the Kadamba dynasty. After the 4th century A.D. the place declined in prosperity, the final blow given to its existence being probably from a great earthquake which threw massive boulders on the outlying parts of the town and caused also extensive damage by fire. Local tradition states that there was a great town called Chandravalli in the now uninhabited valley and that the destruction of the town was caused by an earthquake and a fire—due to the revengeful spirit of the ghost of a murdered Brahmin which had come to live close to the town.

Chandravalli Coins.—A complete account of the evolution of political and cultural history in this Satavahan town, the life of which extended from about 400 B.C. to about 300 A.D., has now been worked out by a study of thousands of little antiquities dug out from the place. Two classes of finds, coins and pottery, are particularly interesting as one of them has helped in the reconstruction of its chronology and the other promises to serve as an index to prehistory. The series of coins begins with square pieces bearing punch marks collected from the lowest Satavahana level. Then we commence to get a series of clay tablets and coins bearing a number of names in Brahmi characters and Prakrit language. The clay tablets have the legends 'Amarasa Magarilasa' 'Sadakana malayasa sebasa,' etc. The earliest coins which bear legends are those of the Maharathis and the many names show that there must have been several generations of them ruling over the place. Some of the legends read thus: 'Sadakana kalalaya maharathisa,' 'Sarajakana kalalaya maharathisa,' 'Haritiputra vilivayakurasa maharathiputasa,' etc. The Roman coins that occurred with some of these can be identified as those of Augustus Caesar and of the early Antonine Emperors covering a period corresponding to the 1st century A.D. Thereafter we come to the next layer which yields coins bearing the names definitely of Vilivayakura Gotamiputra Satakarni and Pulimavi, and we know that they were ruling in the earlier half of the 2nd century A.D. The latest Satavahana level has yielded both coins and seals bearing the name of Yajnasri Satakarni and of some other minor Satakarnis.

Numismatic Index.—The careful stratigraphical study pursued at Chandravalli and the fortunate occurrence of hundreds of coins belonging to a datable series gave us the opportunity of fixing the dates of the other finds. With some approximation, I could now fix the dates of the brick built basements of buildings which overlap one over another, of the sizes and composition of the bricks themselves and the roofing tiles which had collapsed into them and the numerous small objects found in each layer in association with the datable coins. I tried to trace the evolution of the objects in imitation of the method adopted by my master, Sir Flinders Petrie, in his study of Egyptology. Since sometimes the layers were thin and ash pits of upper layers sank into lower ones and owing also to the fact that at my first independent excavation I was confronted with a highly complex site involving a minute study of stratification, I felt often overwhelmed by the amount of new material that was turning up. It was only the occurrence of the friendly coins that led me by the hand in the course of the excavations. Even if occasionally I have made the mistake of cutting a thin floor and mixing up the antiquities of an earlier Satavahana period with a later one, even if my conclusions about the evolution of objects in the Satavahana period could be accepted only as a hypothesis to be verified by subsequent excavations, I feel confident that so far as the Satavahana period as a whole is considered, we know the antiquities and can describe them correctly. These objects have now been studied under the following heads: The situation, the orientation of the town, the buildings, the coins, pottery, beads, implements, art work, natural objects, etc. A monograph on Chandravalli is in the course of preparation. A summary of the results only can be given here.

Orientation of the town.—As I have previously stated the town appears to have begun as a village of the Pre-Mauryan times with its centre to the east and the south-east of the central rocks and to have grown so as to occupy the several valleys close to the Chitaldrug hill on the east, the Hulegondi gorge on the south, and the Kirubanakallu hill on the west and to have at one time extended during its greatest prosperity close to the hill of Cholagudda on the north. The main roads ran from the north to the south branching off from the highway connecting the Chitaldrug plains with Holalkere and extending on the south to the hills. Cross roads appear to have proceeded east and west. Perhaps the most important road passed by the side of the present water course southward to the bund of Mayurasarma's tank. The latter was perhaps one of the last of a series of tanks constructed by damming the gorge and was the primary source of water supply to the town. The cup shaped valley to the south of the dam has the good fortune of getting rain both from the north-east monsoon and from the south-west monsoon and thus it may be imagined that the reservoir was pretty well supplied with water. The existence of a neatly built covered stone drain underground in some parts of the town led to the conclusion that the town got its water supply by what is known as the 'karanji' system of fresh water drains with brick-built cisterns here and there. The discovery of small pottery vessels at the bottom of one of these cisterns showed that they must have acted as shallow wells supplying fresh water. In addition to these there appears to have been a series of deeper wells in the backyards of the houses, which perhaps served to supply water for washing and bathing purposes.

The Buildings.—The most important buildings appear to have faced the main road with their front doors towards the east or west, while smaller houses had their openings northward or southward into the cross roads. The basements of many houses as also the lower parts of the houses were constructed of bricks of large sizes well fired in kilns and exceedingly strong. These bricks were built in a way resembling English bonding. One large house in Baralagondi, which has walls nearly three feet thick and was perhaps the ruler's house, appears to have had an upper storey. On the ground floor was a large hall opening into a verandah running round its western half, the verandah being supported by a number of pillars placed on brick-built foundations. The outer part of the town consisted of huts with mud walls built on rubble foundations. In the most prosperous part of the town there can be distinguished three distinct layers of houses which may on the evidences available inside them be assigned to the early Satavahana (2nd and 1st centuries B.C.), the middle Satavahana (1st century A.D.), the later Satavahana (2nd century A.D.) epochs. In the upper Satavahana basement, free use appears to have been made of the bricks mined from the lower levels.

Pottery.—Chandravalli has yielded a large amount of pottery and an enormous quantity of potsherds. For the three Satavahana layers and the two distinct prehistoric layers below them, I tried to collect information about the nature of the pottery. Satavahana pottery abounds in wide-mouthed cone-shaped drinking cups the like of which can be seen as far north as contemporary Taxila, spouted pots some having handles, thick-rimmed wide-mouthed jars often embedded in the corners of rooms with dish-like lids, large basins, etc. Though the drinking cups and other vases are coarse and brown with unpolished exteriors, a good deal of the other pottery is painted bright or dull red with a well distinguished slip and is moderately polished. The relievo and incised ornamentation assumes a great variety of designs. This red polished ware may be said to be almost characteristic of the Satavahana times. In the Pre-Satavahana layers, particularly on the site of the old village, we discovered three lower layers. One which may be equated with about the Maurya period of the 3rd century B.C. possessed polished pottery with a brown slip on the exterior and black colour on the interior, the pottery being thin and strong. In quality it appears to be similar to that collected in the well-known Maurya sites of Northern India. Below the Maurya level, there occurred painted redware pottery or chocolate-coloured ware, brightly polished. Sometimes the potsherds bore geometrical lattice or plant patterns painted in white or light red, particularly on the drinking cups which were now more of the coffee cup pattern and larger. The inside of these cups and sometimes of the outer parts of the mouths were black evidently due to the fact that while firing they had been placed upside down slightly immersed in ashes. Next below the painted ware level, there occurred a level yielding a considerable proportion of brightly polished black ware, black both inside and out, mixed up with small quantities of black and brown ware. We gathered that now we were in the pre-historic iron age level, and that since the area in which this black ware occurred was small, the settlement was only a village at that time.

Beads.—Chandravalli has yielded a large quantity of beads of various kinds a full study of which is yet in the course of being made. Mention may however be made on this occasion of some of them. Glass beads of various kinds, generally opaque but variously coloured, including blue, yellow and green, pearl beads often partly decomposed, corals often cylindrical in shape, faience beads, coral red in colour in imitation of coral beads or blue in colour, barrel shaped crystal beads, carnelian beads, agate beads, onyx beads, jadite beads, bone beads, etc. The shapes are also varying. A few shapes are: cylinder, wheel, roundish barrel, pear, ellipse, round, barrel with flat sides, amalak, etc. I know that this brief statement would not satisfy the scientific world. I hope scholars will look for further information in the monograph on the subject which is to be published by the Mysore Archaeological Department.

Implements.—Though stone, copper, brass and other metals are known, the largest number of implements are made of iron. The large quantities of nails picked up in the excavations bear witness to the extensive use of iron for wood work. The nails are generally flat, square in section and longish and may be described as being of three kinds: knob headed, those used for doors, etc., flat headed, and large quantities of bent headed nails the head being flattened and bent to one side and evidently used for pinning wooden planks to rafters on the upper floors of the houses. Numerous pieces of swords, spear-heads, arrowheads, iron rods, knives, pipes, spoons, ladles, chop-knives, etc., have been collected. Enormous quantities of iron slag can be collected in almost every layer showing that the iron industry was one of the most prosperous in the town. There are one or two pieces which suggest the sparing use of steel; the material is being subjected to further study. A fuller examination of the specimens has yet to be made. The metalsmith's art had advanced greatly and we are led to think that rare metals were imported for making alloys. For instance, on a chemical analysis, the lead coins have yielded small quantities of antimony; and it may be guessed that the latter metal was imported from Burma or elsewhere for stiffening the coins as in the case of modern printing lead.

Ornaments.—Varied materials were used for making ornaments. Some ornaments may be mentioned. Gold ear-pendants made by turning a gold wire spirally round and round in order to make a fine flat disc, gold ear-rings, ruby beads, crystal beads, copper finger rings sometimes of the wavy pattern, bangles of glass, black, blue, green and yellow. Some of these are made of several multicoloured bands, straight or twisted like ropes and welded together. Clay rings and crescent shaped clay pendants covered over with a gilt powder are interesting ornaments, evidently worn by the poor.

Art work.—Several ornamental copper pieces with interesting designs appear to have been used for wooden boxes. Parts of burnt clay statuettes, stone pieces of figures and one highly polished alabaster piece of an unknown sculpture, ivory objects, bone dice, a copper chain, jingles, writing stylus of steel, arrow heads, etc., have also been collected. These show that there was a high culture with practically all the amenities of the old type of civilized life.

Chandravalli and Prehistory

Prehistoric levels.—I am aware that these details of the Satavahana town would be matters of less interest to the Prehistorian than actual objects assignable to prehistory. But since our progress in knowledge can be only from the known to the unknown, I plead that I have tried to build up some knowledge of prehistoric Dakhan standing on the foundation of Satavahana antiquities. Below the Satavahana town, as mentioned by me already, there were several layers. One yielding well-polished bicoloured pottery, I could assign to the Maurya period; and since, in north India, Maurya pottery has not been known as ornamentally painted and plenty of such painted redware pottery was to be found at Chandravalli, I concluded that a short time before the Mauryas, perhaps in the 4th or 5th century B.C., this kind of painted pottery with ornamental designs was in vogue at Chandravalli. Next below this level the occurrence of burnished full black ware led me to think that we were somewhere in the prehistoric iron age of the Dakhan. Then came knowledge of the lowest Chandravalli layer.

Neolithic.—The Chandravalli valley, with its abundant supply of game and water, its numerous caves and good protection, could be guessed to have been the home of man from very early prehistoric times. Since some neoliths were picked up on the surface and many more were washed down by the rain water coursing down the hill sides and flowing through the deep water courses almost in a flood immediately after the rains, we were led to think that the valley passed through neolithic culture sometime during its early history. The occurrence of a few fragments of neoliths in the Satavahana houses puzzled my mind and occasionally led me to wonder what use the iron using Satavahanas had for trap stone celt pieces of exactly the neolithic kind and that too broken pieces. The thought came to me that these pieces had been collected as play things, curios or objects of worship on the hill sides and in the digging of wells, etc. A careful search among the caves on the hill sides yielded neolithic celt and pounder pieces and excavations near abouts showed that there had been close by neolithic implement factories. My problem was now to find out if, below the prehistoric iron age village, the neolithic layer could be struck. Digging underneath one of the most thickly housed areas where no traces of buildings could be seen any more, we found that every basketful of earth, though it looked like natural gravel, yielded on close examination small bits of pottery. The problem was how could pottery get in into this gravel bed. At last we came across a level in which a number of neoliths were collected. An experiment, made in this direction in the presence of Dr. E. P. Metcalfe, Vice-Chancellor of the Mysore University, resulted in success and a neolith was obtained from below the Satavahana ruler's house at a depth of 12 feet. Thus I concluded that long before the prehistoric iron age town the Chandravalli valley had known a neolithic settlement. No paleolithic layer or microlithic layer was discovered at Chandravalli.

Cistveans.—Particularly interesting was a small field of cistveans round about the central rocks, which on opening yielded evidence of both cremation and of burial and a large quantity of funerary ware was collected from one of them, the pottery being mostly of the polished black slip variety. Three shapes particularly attracted my notice. One was an elephant footed urn containing the relics of the dead person, another constituted several small pots having three feet each and the third was the occurrence of large cups with conical knob headed black lids. From my knowledge of Bruce Foote's collection I guessed that they belonged to the prehistoric iron age. In the midst of these burials there was a large boulder on which was a crude carving of a large tiger its body being shown by the lattice technique. I guessed that it was exceedingly ancient and went back probably to the neolithic times.

Chandravalli and prehistory.—After the excavations it was clear that Chandravalli was mainly a historical site leading on to three thin layers assignable to prehistory. That there was a prehistoric period in the Chitaldrug District and that it was long enough to permit of a development of pottery from the neolithic to the polished blackware of the early iron age and the painted redware of the later iron age was clear. But the material for study was not abundant. Chandravalli stood at the threshold of history and pointed to prehistory. It could not itself take us far into the knowledge of prehistoric Dakhan.

Brahmagiri Excavations

Other sites.—In order to get into touch with prehistory, it became necessary to find some other sites connecting the historic with the prehistoric. Of the sites noticed by me in the course of my explorations, I may mention only a few. At Haralakote in the Srinivasapur Taluk of the Kolar District there was a site, containing cromlechs and burnished blackware pottery. To the east and west of the Kolar hill, particularly on the west near Garudanahalli, there were large fields of cromlechs, yielding variously shaped, burnished blackware and bicoloured pottery. Some of these had been excavated by some officers of the Kolar Gold Mines many years ago and the antiquities had been shipped away from India. Near Chikjala to the north of Bangalore was another site of cromlechs. It was noticed that close to many important groups of hills in the eastern half of Mysore, near the foot of the hill, where boulders of various sizes could be collected there were fields of cromlechs. One of the most recent finds has been a large field of very old looking cromlechs close to Parandapalli about a mile east of Robertsonpet in the Kolar Gold Fields. A few miles to its north has been found another old site consisting of a prehistoric inhabited settlement near Hungunda. There is very good reason to think that these two sites are connected with prehistoric gold mining and may contain evidences of foreign contacts. It is proposed to subject these sites to a careful study at the earliest opportunity. But of all the sites, the most interesting appears to be the Brahmagiri site in the northernmost corner of the Mysore State. This I selected for excavation. A fuller account of the discovery and survey of this site has been given by me in the Half-Yearly Journal of the Mysore University, Volume I, Part IV, pp. 45 to 55 (1940).

Brahmagiri.—What attracted me to Brahmagiri was the existence of three copies of Asoka's minor rock edict No. 1 near Siddapur, a place between Bellary and Molakalmuru, the northernmost taluk town of Mysore. These inscriptions mention that the Emperor's message was conveyed by his officers at Suvarnagiri to his officers at Isila. Evidently, the latter published the edict in three different places close to their town. I guessed that Isila must be close to these inscriptions and searched the neighbourhood for signs of the old site. Even on the surface there was abundant evidence of an ancient town. Brick structures were noticed in the ground here and there, natural caves inhabited probably by hermits or monks were explored, characteristic Mauryan pottery was collected and the site of the Mauryan town on the right bank of the Hagari river known also as Chinna-hagari, 'the Golden Hagari', was noted. Often the archaeologist seeks something and he finds more than he bargained for. Thus it happened when the explorer went out to find a Buddhist stupa and found the Indus Civilization. As at Chandravalli, I was surprised at finding along with the Maurya objects, polished blackware pottery and even neoliths near the mounds by the side of the hill slope. At a short distance there were whole fields of cromlechs, cistveans and dolmens to the tune of several hundreds and the whole site covered more than four square miles. In searching for Isila we had discovered a site reaching back to an immensely greater antiquity.

The study of Brahmagiri.—The newly discovered site was subjected to a methodical study. A rough sketch plan was prepared of the whole neighbourhood and the fields, jungle tracks and hill slopes round about were searched for evidence available on the surface. It was discovered that the ancient site extended nearly half a mile or so to the west of Asoka's Brahmagiri rock inscription and more than a mile to the south-east and east. The old site was in the shape of a crescent surrounding the northern nose of the hill where the edict stood. In the lower plains, it was noticed that the rice fields had encroached on the old site thus covering up a good part of the old town. Large numbers of cromlechs which lay in the lower levels had been destroyed and removed, while those only which stood above the level of the irrigation canal remained available for study, particularly on the south-east. The mounds near the hill slopes had been converted into dry fields used for groundnut cultivation and could be studied only after the harvest. When a real study of these mounds was conducted, they yielded as already mentioned antiquities which ought properly to belong to different stages of culture, extending from the Mauryan backwards into the unknown prehistoric ages. We decided that a careful stratigraphical study of trial pits and trenches was necessary before we could guess more correctly the contents

16

of the ground. We excavated across a promising looking mound one trial trench measuring 40′×6′ on the surface and reached to a depth of 18′, where we struck boulders and the bed rock. The result obtained in this trench was corroborated by another sunk at a little distance at right angles to the first one measuring 25′×6′. These helped me to form a hypothesis about the stratification of the place. To the south-west of the rock inscription we selected some mounds into which we sank two pits. One of these was intended for a close study of pottery sequences. Though few large pots were discovered intact, numerous potsherds occurred in these pits and a hypothesis has been now formed about the evolution of pottery, particularly so far as its quality is concerned, though not of their shapes. In order to know the contents of the cromlechs and the period to which they might be assigned I selected about eight of them and excavated them. We sank one or two more pits here and there to get a little more information about the Mauryan town. Much of this work was done in 1931 and continued in 1940, and I am now in a position to say that the Brahmagiri site is one of the most interesting I have seen and that it has revealed to us how the prehistoric cultures of the Dakhan have been linked on to the Mauryan period. I am now placing my provisional conclusions before the world of science and I hope that these results will be verified, checked, corroborated and improved by future excavations in the Dakhan.

Prehistoric Town of Isila

Isila Town.—Historically it is known that the Maurya power was in occupation of the Dakhan in the days of the emperors Bindusara and Asoka, the dates being approximately between 298 and 232 B.C. According to Asoka's rock edict No. 13, in the country corresponding to modern Dakhan, three subordinate peoples, namely the Petenikas (Paithan), the Andhras (Nagarjunikonda) and the Pulindas (Banavasi) are mentioned as being within the empire's borders, while the Satiaputras (Chitaldrug District ?) are mentioned as being outside. Suvarnagiri is considered to have been the capital of the Dakhan province and several suggestions have been made for its identification. Dr. Fleet thought that it might be Kanakagiri in south Hyderabad, Mr. Yazdani thinks that it may be Maski in south-west Hyderabad and Dr. C. Narayana Rao suggests that it may be Sonnagiri close to the Yerragudi group of Asoka's rock edicts. There is no doubt that the district town of Isila was close to Brahmagiri hill and that it was within Asoka's empire. As evidence of Asoka's times at Isila, we have found the three copies of Asoka's minor rock edict No. 1, the excavated basement of a brick built apse-backed Chaitya or

Buddhist temple half way up the hill behind the monks' caves (unearthed by Mr. A. Srinivasa Iyengar, M.A.), and the occurrence of polished fine quality pottery, often bicoloured, such as is found in the Maurya sites elsewhere in India. The series of large natural caves near Asoka's rock edict might have been the dwelling place of hermits or Rishis at first and later of Buddhist monks. This perhaps gave the town the name Isila or 'the place of the Rishis'. But the excavations revealed, at least in one of the pits, as many as nine different floors showing that the town must have flourished for several centuries. It is possible that the period of Maurya supremacy was only the last or more probably the penultimate period in the history of the town which may have decayed and disappeared somewhere about 200 B.C. when the supremacy of the Dakhan passed from the Maurya into the Satavahana hands. It is probable that Isila was a frontier town which decayed in prosperity just when Chandravalli and other places grew in wealth and splendour. But if Isila decayed in the early Satavahana days having had a more prosperous period during Maurya rule and Pre-Maurya days, her life at least began many centuries before. Assuming, just for approximate calculation, that ordinary houses are rebuilt once in about fifty years, nine floors would account for more than four centuries of life. Thus it is possible to guess that the lowermost levels reached near 'Garegundu' take us back to almost the seventh century B.C., if not earlier. We have not yet been able to collect enough specimens to trace the growth of culture during the many centuries of the existence of the town of Isila, but we have been able to get an idea of the kind of potsherds yielded by the various levels. For these pottery studies, I am indebted to the assistance of Mr. L. Narasimhacharya, M.A., who was in charge of the particular excavation in question and prepared the records, assisted by Mr. G. Sridhar Dikshit, B.A. (Hons.).

Isila Culture.—Among the nine floors observed in the excavation of the house sites near 'Garegundu,' the following varieties of pottery were noticed as we excavated downwards from the top. The bottom has not yet been reached.

1. Largish gourd shaped pots with rough exteriors; relievo and incuse ornamentations on unpolished redware pottery. Evidently, they belong to the last days of the town. Along with these occurred painted redware probably belonging to about the early Satavahana times.
2. Polished fine pottery, yellowish brown outside and black inside strongly resembling Maurya pottery of Bhita and elsewhere.
3. Redware pottery, some specimens of which, particularly the drinking cups, were painted in white

with lattice, geometrical and plant patterns, or had incised tooth and leaf ornamentations.

4. Tanware pottery with the designs painted in dark red.
5. Brownware pottery with the designs in dark violet.
6. Polished blackware with the designs in white, also bicoloured pottery plain or coloured inside.
7. Well burnished pure blackware occurring along with unpolished brownware. This layer particularly was pretty thick.
8. Polished pottery, with multicoloured mottled ornamentation, distinguishable among the colours being red, yellow, blue and black. Coarseware also; comparatively less of polished blackware.

Further excavation was stopped at this stage owing to the want of room and the approaching end of the season. I guess that such a variety of pottery and such a development of tints and colours could have occurred only in a period of time spread over many centuries. It was evident that the Dakhan was passing through civilized life using iron implements and high class pottery some centuries before the Mauryas came into contact with it. We knew that we had come across a settlement belonging to a comparatively long existing Iron Age of the Dakhan. The details of this type of culture are being studied. Provisionally it has been called 'Isila Culture' for purposes of identification.

Foreign influences.—Two particular types of pottery, however, deserve special mention as they suggest foreign influence. One of these is painted with a red slip and ornamented in dark violet with plant and wave designs and is outwardly remarkably similar to some Indus valley pottery, though unlike it in having a black core inside the walls. The other has chequered and other patterns in black over a buff background as in so much of the third millennium B.C. pottery of Sindh, Sumer and Crete. Its inner face bears the impress of cotton cloth. These two are unlike the usual painted ware found at Chandravalli and other places in the Dakhan and suggest foreign influence though they may perhaps have been locally produced. Since the Indus Civilization used gold, jade and other materials which were probably imported from the Dakhan, we are justified in looking out for possible connections between Sindh and Mysore in prehistoric times. The potsherds in question are accordingly being subjected to the study of experts.

Index trenches.—More surprising and more definite information was secured from the two trenches which as I have mentioned we excavated into the mounds on the hill side to the south-east of the town. When the first trench was dug, the workmen were inexperienced and sometimes mixed up lumps of earth belonging to the upper layers with those of the lower ones. But when the second trench was excavated great care was taken to see that no such intermixture occurred. In this trench particularly it looked as if we had obtained a correct index of the contents of the mounds. The finds of this trench were somewhat as follows, proceeding from the top downwards : (I am indebted for these details to the records of my assistants Mr. K. Narayana Iyenger, M.A. and Pandit R. Chakravarti). The following is a summary of their records:

1. Top layer—mixed specimens consisting of blue glass bangle pieces, jade bead, painted potsherds with designs and a fragmentary quartz crystal implement. This level was useless for stratigraphical study, since it was on a slope leading from the hill-side and contained a heterogeneous variety of antiquities brought down by the rains and perhaps turned up by the ploughshare.
2. Stone foundations, painted potsherds, stone bead, bone bangle pieces, earthen crucible, iron pieces, iron slag, glass slag.
3. Shell beads, stone beads, terra-cotta objects, red and black polished ware painted with the designs, red, black and tan coloured and chocolate coloured ware.
4. Depth 2 feet—Tan and black, and red and black potsherds, tanware, iron slag, a neolithic celt piece.
5. Depth 3 feet—Stag's horn, burnt stones, perhaps belonging to a fire place, red and black painted ware, some with designs.
6. Depth 4 feet—A floor. Red, black and tan painted ware. Coarse piece of grooved roofing tile, painted polished ware—red, black and tan; coarse gray-ware.
7. Depth 5 feet—Agate bead, quartz pieces, neolith, painted red potsherd.
8. Depth 5½ feet—Shell bead, quartz flakes.
9. Depth 6 feet—Neoliths, microliths.
10. Depth 6¼ feet—Painted potsherds, neolith, buttonlike stone piece, microlithic borer.
11. Depth 6½ feet—Some human teeth, microliths.
12. Depth 7 feet—Charcoal pieces, quartz pieces, small neolithic celt.
13. Depth 7½ feet—Ashy layer, gray unpolished pottery, microlithic scraper.
14. Depth 8 feet—Microliths, quartz pieces, round whet-stone, grayware pottery.

15. Depth $8\frac{1}{4}$ feet—Microliths with a small neolith and chipped quartz pieces.
16. Depth $8\frac{1}{2}$ feet—Microliths, stone pounder, grayware pottery, coarse grained and full of mica.
17. Depth $8\frac{3}{4}$ feet—Quartz pieces, microliths, chipped stone implements, coarse pottery; a fire place of rough stones.
18. Depth $7\frac{1}{2}'$ to 10′—At one end of the pit coarse wide mouthed burial urns with skeletal remains of young children including the bones of the limbs and parts of skullcaps. In one of the urns was found a drinking cup of pottery with a black slip and slightly polished.

Neolithic and Microlithic Ages

Prehistoric stages.—In the excavations just described it was evident that the upper town layers were comparatively thin, while the lower layers of the prehistoric period were much thicker. The layer corresponding to the iron age was clearly identifiable, its pottery being characterized by its varied painting and polishing. In the later stages of what may be called the full iron age, the colour most popular is red and next to it tan or chocolate. Potsherds painted with geometrical and other designs also occur in these levels. Then we descend to the early iron age when neoliths are yet being used. Here tanware is more common than redware and polished blackware and chocolate coloured ware also occur. The next lower level is the full neolithic yielding largish well-ground neolithic celts and having no trace of iron. Along with coarse pottery this level yields finely polished blackware. It may be surmised that blackware began to be used in the neolithic period and continued to be used in the iron age. The continuous use of polished blackware commencing in the neolithic period and found again in the iron age proves the continuity of the iron age with the neolithic age. In the first trial trench whose evidence I have not used for this note, copper slag pieces and a copper fish hook were recovered from the upper part of the neolithic level. In spite of the opinion of Bruce Foote to the contrary, I have been led to form the hypothesis that copper and iron were both in use in small quantities from almost the middle of the neolithic period (c. 4000 ? B.C.), and that iron very soon superseded copper and became more popular. In the caves around Chandravalli, I have noticed the occurrence of neolithic implements along with evidence of very primitive iron smelting. This lends support to the view that neolithic man in the Dakhan commenced his use of iron when yet he was using his polished trap celts and pounders—perhaps along with small quantities of copper.

Microlithic age.—In the neolithic age it is possible to distinguish between the full neolithic with its large celts, pounders, mealing stones, adzes, etc. and the early neolithic, in which the celts are often chipped all over the body and ground only at the edge. Others are between two and three inches long and are made of sandstone and other materials of a texture much softer than trap. These small celts are generally flat sided and thinner and have often flattish though narrow tops. They look almost like toys. The fact that in association with them occur quartz flakes and pigmy stone implements leads to the conclusion that there was the beginning of neolithic industry during a microlithic stage of culture. This was one of the most unexpected surprises of the excavation, for it was now definite that instead of microliths being stray occurrences met with near the surface, a large and long lived level had been struck, which yielded plenty of microliths and evidence also of a local microlithic industry, such as rejected quartz flakes, chipped cores, etc. The occurrence of bone beads and of coarse grayware pottery containing clay mixed with mica, which easily degenerates under the long continued action of moisture, was something new in the prehistory of the Dakhan. Microliths had no doubt been collected in various parts of India, but a regular microlithic settlement and one definitely underlying and leading on to the neolithic strata was a find worthy of further study.

Roppa Culture.—The discovery of the microlithic settlement suggested that at Brahmagiri at last we had found something connecting with the late mesolithic period. But of the various mesolithic cultures, this microlithic culture, which, for identification, I have provisionally called 'Roppa Culture' after the nearest village, appears to correspond much less with the late paleolithic Azilian stage of Europe or with the Gafsian stage of north-west Africa. The definite presence of coarse pottery and of a finely shaped shoulderless tanged crystal arrow-head, the burial of children's bones under the kitchen floors in wide mouthed coarse grayware urns, the occasional presence of spouts and darkware slip-painted pottery, of buffalo and horse (?) bones and stone pounders, hinted at first at greater affinity with the later microlithic cultures resembling the Campignian of France. A closer study revealed that the split-edged pick, the painted pebble, the incised ornamentation on pottery and other characteristics of the Campignian culture appeared to be absent. So we concluded that we were face to face with an early neolithic-microlithic culture which was different from anything till now known to prehistory, but was parallel to the Campignian. European archaeologists have generally assigned the Campignian culture and other related microlithic cultures to about 8000 or 6000 B.C. It was extraordinarily interesting to think that a level had been discovered containing evidence of a human settlement in the Dakhan in the late microlithic period.

CROMLECHS

Cromlechs.—As stated by me before, the most important objects met with during the course of the overground survey were the groups of cromlechs, dolmens and cistveans. Externally, these resembled in general appearance the groups found in many other parts of the Dakhan plateau and especially in Mysore. Some cromlechs showed instead of the single circle of rough boulders, double circles of stones the intervening space being filled in with rubble. Only a few table stones were visible above ground, and in the case of a number of cistveans without the table stones and the circles of stones, the tops of the stone boxes with their side slabs projecting anti-clockwise in the swastika fashion could also be seen. Occasionally a funerary urn buried in the earth was also just visible in the ground. It was clear that this group of prehistoric objects belonged to a great necropolis which must have been in existence and use for several hundreds of years. The people of the adjacent villages called these structures 'Maurya dwellings' and it was significant that the name Maurya was in use in such close proximity to a genuine Maurya town. It was surmised that while the people of the Maurya times may also have been buried in the locality, the great bulk of the cromlechs which clearly exhibited what looked like a development of several centuries belonged to the prehistoric period of Isila town. A number of these cromlechs were selected and excavated with the assistance of Mr. M. Seshadri, M.A. Where necessary, the dolmens were blasted, the circles of stones were removed and the cistveans constructed with large flat slabs were made available for study. It was found that the cists had their slabs projecting in one direction anti-clockwise as in a swastika and that usually on the east or south-east, the wall slab had a hole about 15 to 18 inches in diameter and that this was covered over on the outside with a shutter slab. The contents of the cistveans were examined in stages of two or three inches depth. It was found that below the top layer of earth there were thick layers of lime stone intended perhaps to prevent the buried corpses from being attacked by vermins and also to help their faster decomposition. Below the limestone layer often commenced to appear varied kinds of pottery placed around the walls on the inside with the skeletons themselves lying in the middle. Some of the cists had been divided into two or more chambers by cross slabs and each chamber contained a separate burial. The bottom slab was reached generally at a depth of four to six feet.

The burials.—That the cromlechs and cistveans were burial chambers was clearly established by the occurrence of human skeletons in nearly every one of them. Only one fractional burial was noticed. It appeared to be that of a boy whose disconnected skull was found placed erect on his chest. A few cases were of multiple burials, a number of corpses being packed into single chambers. One of these contained as many as four full grown men's skeletons with some bits of iron weapons. They might have been soldiers killed in a skirmish and buried together. In one cist a husband lay on his back with his leg bones folded in padmasana as in modern south Indian burials, and his wife lay to his left on her right side with her arms embracing him. This looked like a case of 'sati'. A sword blade was recovered close to the man's skeleton. In another cist the skeleton lay slightly turned to the right with a battle axe by its side and a large number of pots around it. In still another cist, one hand of the corpse was placed on the mouth of a pot. In nearly all the cases, the head of the corpse was to the north or north-west and the feet towards the south or south-east facing the hole in the wall slab.

The Funerary Pottery.—An attempt was made to recover some of the skeletons but many of the thinner bones and especially the skull bones which had become soaked in moisture percolating from the canals and rice-fields had become exceedingly brittle and went to powder even with the lightest touch. Since no arrangement had been made for recovering these skeletons by the shellacing process, photographs of the skeletons were taken as far as possible in situ and they were once again covered over with earth. The weapons found with the corpses and most of the pottery were, however, collected, often along with the decayed contents. The pottery generally consisted of coloured ware painted red and polished or more often richly polished blackware. In two burials a number of pots, each with three short legs, were collected though these pots were much smaller than the footed pots found in some other prehistoric sites near Bangalore and Kolar, and exhibited in the Government Museum, Bangalore. In one case only a largish redware pot was found with the lattice design painted on it in white. It was clear that a fuller study of the necropolis could yield much more information about the people living in prehistoric Isila in the iron age. No coins or neoliths were found in any of the burials. It was also surmised that a sequence study of prehistoric burials might prove profitable since it looked as if there was almost an evolution in the burials in their shape, size and mode and also in their pottery. It was also clear that wherever a field of cromlechs was found, as in so many places in the Dakhan, a prehistoric dwelling site ought also be found in its proximity. It is proposed to continue further studies at Brahmagiri next spring.

OTHER DAKHAN SITES

Hyderabad sites.—On this occasion it is my pleasant duty to acknowledge that in December 1940 when the Osmania University invited me to deliver some extension lectures on the 'Archaeology of Mysore,' I was enabled by the kindness of His Exalted Highness' Government and the courtesy of Mr. Ghulam Yazdani, the Director of their Archaeological Department, to visit a number of ancient sites in the Nizam's State and particularly Maski in the south-west of the Raichur district, in the company of Mr. Khwaja Mohamed Ahmed, their indefatigable excavator. Mr. Yazdani has since then published the antiquities collected in the place with a note in the Hyderabad Archaeological Reports and also discussed them in his Presidential Address to the Archaeology Section of the Lahore session of the Indian History Congress; it is not necessary for me to say much about them. It is a great discovery following on Chandravalli and Brahmagiri and I believe if fully studied Maski has much to tell us. Its antiquities, in my opinion, extend from about the 4th century A.D. back through the Satavahana and Maurya periods into the prehistoric iron age and even farther back into the neolithic and microlithic ages. It is a pity that a strati-graphical study of the place has not been possible and that the antiquities have been found in a seriously mixed up condition. But it is a patent fact that the Brahmi inscriptions in cave characters found in large numbers around the mouth of the Ascetics' cave, the Satavahana coin bearing the legend 'Maharathiputasa', the Mauryan inscription, the painted and ornamented pottery—redware and blackware, the neoliths and the huge number of microliths collected in the place, could not all belong to one cultural epoch. If Maski has yielded numerous finds, Chandravalli and Brahmagiri have given us the index for classifying them and have shown what we might look for in a careful stratigraphical study of Maski and other sites. I would urge the Hyderabad Archaeological Depart-ment to once again try some more excavations at Maski in order to find out if the layers yielding these various kinds of finds do not lie in a series one below the other as they have been found to lie in the Mysore sites. If Maski can confirm Brahmagiri, it will help to establish firmly the provisional conclusions suggested by the Mysore excavations.

Sites in British India.—Of prehistoric antiquities coming from Adichanallur, Perumbair, Coimbatore and elsewhere, the Madras museum has already a good collection. More sites are in the course of discovery. A Satavahana city has been found at Kondapur, 40 miles north-west of Hyderabad city. From British India comes the news that Mr. R. S. Panchamukhi, Director of Kanada Research, Dharwar, has brought to light two sites, one near Belgaum and another near Bagalkot, both of which show extensive occupations yielding terra-cotta and shell objects and above all the peculiar painted pottery with white lattice patterns on red background recovered from the prehistoric iron age levels at Chandravalli and Brahmagiri. The Director-General of Archaeology has kindly informed me that Rao Bahadur C. R. Krishnamacharlu, Superintendent for Epigraphy, Madras, has also found large quantities of such pottery in two sites in the Anantapur District. We can conclude that what I have called 'Isila Culture' or the prehistoric iron age culture of the Dakhan extended from the northern districts of the Mysore State to the south-western districts of Hyderabad and from the south-eastern districts of the Bombay Presidency to the Ceded Districts of the Madras province. The existence of prehistoric sites has been noted even much beyond this area and it is now necessary to verify the results already obtained at Mysore and add further information to our knowledge of Dakhan's prehistory by co-ordinating the efforts that are being made in four different political areas. I am hopeful that under the wise and sympathtic lead of Rao Bahadur K. N. Dikshit, the Director-General of Archaeology, this work will progress further.

Conclusion

I may now state summarily the provisional conclusions I have drawn from the study of the prehistory of the Dakhan, as mentioned in the previous paragraphs. The dates mentioned are widely approximate and purely provisional and suggestive.

1. There is evidence to confirm Bruce Foote's conclusion that the Dakhan passed through some stages of lower paleolithic culture parallel to the Chellean, Acheulean and Mousterian epochs of Europe 50,000 to 30,000 years ago and possibly through a stage corresponding to the Magdelanean (c. 13000 B.C.). No stratigraphical study of these cultures has yet been possible.

2. Some time later a microlithic culture spread over the Dakhan using pigmy stone implements along with coarse greyware pottery and shell and bone beads. This industry is different from the other known mesolithic industries of the world and appears to be parallel to the Campignian and other later mesolithic or early neolithic types of 8000 to 6000 B.C. in Europe.

3. In the microlithic period, the art of polishing implements spread over the Dakhan until at last harder stones were polished and shaped into celts, pounders, etc. and the full neolithic period began and flourished (6000 to 4000 B.C.?). The characteristic pottery of this time was polished blackware which is found along with coarser types.

4. Sometime in the neolithic epoch, copper and iron appear to have come into use and the copper age possibly

flourished for a comparatively short period (about 3000 B.C.?). During this time, small quantities of iron appear to have been in use.

5. In the late neolithic period the method of producing larger quantities of iron was discovered and its use spread over the Dakhan. (About 2500 or 2000 B.C.)

6. Very soon the Dakhan entered upon an iron age in the earlier part of which stone implements were in use along with iron. (About 2000 B.C.) Later on, in the full iron age a prehistoric culture of high quality developed. (About 1500 to 500 B.C.) Polished blackware pottery was popular during a considerable part of the period, then came coloured ware in the shape of tanware and redware. Commencing from the period of the blackware and extending to the earlier part of the redware period, the art of ornamenting drinking cups and other vessels with lattice, wicker work and plant patterns in dark-red and white was in vogue. The cromlechs and other megalithic structures appear to belong to the period extending from the early iron age right on to the Maurya times, and their evolution can now be suggested. (2000 to 200 B.C.)

7. Coloured and polished pottery, often red or brown outside and black inside, continued to be used during the epoch which we can definitely assign to the Maurya times. The art of ornamenting with incised designs and relief mouldings commenced about this period and continued during the succeeding Satavahana epoch. (200 B.C. to 200 A.D.)

8. Satavahana pottery is characterized by redware, somewhat polished and ornamented, often with varied relief and incised patterns. Wide-mouthed drinking cups and large round-bottomed urns become exceedingly common during this period.

9. The existence of civilized town life is traceable from the iron age onward for a comparatively long period of time before we reach the beginnings of history.

10. There now remain to be gathered the details of four stages of prehistoric culture in the Dakhan:

(*a*) the lower paleolithic;
(*b*) the microlithic;
(*c*) the neolithic; and
(*d*) a highly civilized, well-established and widely spread iron age civilization which is connected with the Maurya and Satavahana epochs at its later end.

SECTION OF MEDICAL AND VETERINARY RESEARCH

President :—C. G. Pandit, M.B.B.S., Ph.D., D.P.H., D.T.M., F.N.I.

Presidential Address

(*Delivered on Jan. 5, 1942*)

IMMUNITY PHENOMENA IN VIRUS DISEASES

I thank you for the honour you have done me in electing me to preside over the Medical and Veterinary Section of the Science Congress this year. I have chosen for my address to-day a subject connected with the field of Virus research, for you will agree that some of the most important advances in the field of medical research in recent years have been in the domain of Filterable Viruses. As the subject is vast, I propose to limit myself to one aspect of Virus research—the phenomena of immunity in virus diseases.

Before I proceed to discuss the experimental evidence concerning the nature of immunity in virus diseases, I should like to make a few observations, by way of introduction, on the mechanism of infection, in virus diseases. The viruses are intracellular obligate parasites and their existence depends entirely on their ability to multiply in the tissues of the host they parasitize. One interesting feature in this connection is the remarkable affinity which viruses have for certain organs and tissues of the host. The virus of parotitis has a tendency to localize itself in the parotid gland an organotropic virus. Other viruses show a special predilection, after sometimes causing a transient septicaemia, for the epithelial structures, e.g. foot and mouth disease virus. Some viruses, on the other hand, exhibit a well-marked neurotropism, e.g. Rabies, Poliomyelitis, etc. Levaditi and others originally included vaccinia virus in the epitheliotropic group. They were of opinion that elective localization took place in sites where there was epithelial proliferation, as usually happens due to local irritation or trauma. Ledingham has, however, shown recently that vaccinia virus has special affinities for the cells of the mesoderm. When the virus was injected intradermally, the vascular tissues in the dermis, endothelial cells, and even resting histiocytes were the first cells to be attacked. When the virus was introduced into the peritoneum or spleen, typical lesions appeared in the reticulo-endothelial tissues. No lesions appeared, however, when the virus was injected along with

Indian ink. The reticulo-endothelial system was stimulated by the Indian ink, and the local defence mechanism was probably enhanced in this way. Probably, the same holds true for the fowl-pox virus. But, as Ledingham himself has suggested, this finding does not explain why in variola, after an initial septicaemia, the virus shows a definite predilection for skin. The same holds true for sheep-pox, though in this condition it is not possible to demonstrate the presence of the virus in the blood stream, though the initial focus is probably in the lungs.

In neurotropic viruses, the route of infection appears to determine the final outcome. If the virus travels by the perineural lymphatics, it will eventually appear in the spinal fluid, e.g. herpes. If the spread is by means of the axis cylinders, as in rabies, the virus will be localized in the central nervous system. It is now accepted that infection in Poliomyelitis is by the olfactory tract. Section of the tract will prevent the infection. Leuette and Hudson have shown that if the virus is inoculated intravenously, it is first excreted from the blood stream on to the nasal mucosa. There it enters the endings of the olfactory nerves and migrates to the central nervous system. When the neurons are thus attacked, then, according to the severity of infection, either necrosis of the cell will result, or peculiar changes in the cell will develop giving rise to intranuclear inclusions, (e.g. Herpes) or cytoplasmic changes as in Rabies, the Negri Bodies.

Some viruses are pantropic in their affinities, e.g. Pseudo rabies, or the virus B. The latter virus was accidentally discovered in the laboratories of the Rockefeller Institute. It was present in one of the monkeys under experimental observation, and was transmitted to the laboratory assistants by the bite of the animal.

There are other viruses, however, which do not show any well-marked tissue tropism. Measles, Dengue, Rinderpest, may be cited as examples.

After the virus has gained entry into the susceptible cells, subsequent changes in the cells are determined by the specific characters of the virus. These changes are either in the nature of cell proliferation followed by necrosis, or, in the case of viruses whose action is 'explosive and rapid,' by necrobiosis and lysis of cells. As Rivers has stated 'the balance between the stimulative and destructive tendencies of the virus determines whether hyperplasia or necrosis is the predominant part of the pathological picture'. In smallpox, herpes, etc., there is first cellular proliferation later followed by necrosis. In others, e.g. tumour viruses, extreme cellular proliferation is the outstanding picture. The 'Louping ill' virus, inoculated into the cerebellum of the monkey produces rapid lysis and destruction of the Purkinje cells. It is apparent from this that even though the clinical picture may differ widely in several virus maladies the underlying pathological process shows many striking similarities.

Another important manifestation, due to virus activity which arises in an affected cell, is the development of an inclusion body. These inclusions appear with such constancy in some diseases, e.g. Rabies and Fowl-pox, that they are regarded as being of diagnostic significance. The inclusions are of two types—cytoplasmic and intranuclear. There is, however, no unanimity of opinion concerning their nature. These were regarded by earlier workers, as sporozoa or chlamydozoa. Shortt has made a detailed study of the morphological appearance of Negri bodies. He did not find any indication in favour of the theory that the Negri bodies were the products of nuclear or nucleolar degeneration. No facts were observed to support the view that they were parasitic protozoa, though such a conception could not be entirely ruled out. That they are the cell inclusions of a virus disease is no doubt the orthodox view. It was demonstrated, however, that they had a uniform and demonstrable internal structure, which was the same in whatever animal they were studied, and that they had all the morphological characteristics of organized entities, rather than those of mere agglomerations of elementary bodies. He suggested the possibility that the Negri body was a vegetable organism structurally most closely approaching the yeasts. Recent work on other cytoplasmic inclusions has revealed that some of them at any rate were aggregates of small bodies—the elementary bodies which are now regarded as the actual virus agents. Thus the Bollinger body in Fowl-pox was composed of an aggregation of Borrel bodies, the Guarnieri body an aggregate of Paschen bodies. The inclusions noted in the epithelial cells of the skin of mice in infection with ectromelia virus, and the inclusions in the endothelial cells in Psittacosis, are also probably of the same nature. The nature of intramuscular inclusions, such as those found in Herpes, Varicella, Yellow fever, Virus III of rabbits, Pseudo rabies, etc., is not yet definitely known. They are commonly regarded as significant of virus infection, either latent or active.

It has to be stated in this connection, however, that inoculation of material not containing any virus occasionally produces 'inclusion bodies' or appearances simulating them in experimental animals and in the Chorio-allantoic membrane of the developing chick embryo. In our laboratory, we have studied the response of the chorio-allantoic membrane to inoculation with substances definitely known not to contain any virus. We employed for this purpose bacteriologically sterile suspensions of insoluble substances, such as 1 per cent Keisulghur, 5 per cent aluminium gel, Indian ink, etc., soluble substances such as copper sulphate, normal saline, glycerine, starch, etc., biological substances such as normal membrane, human serum—normal as well as febrile, milk, pepsin, etc., and suitable suspensions of bacteria particularly, *E. typhosus, V. cholerae, staphylococci* and *B. proteus X19.*

The results obtained were interesting. None of the inert substances produced lesions except the aluminium gel. In this lesion histologically there was considerable proliferation of the ectoderm with a tendency to papillation, a much slighter proliferation of the entoderm, and a marked thickening of the mesoderm, with cellular infiltration with fibroblasts. Cell nests were also present. Olitsky and his collaborators have reported similar appearances in the guinea-pig when inoculated with the same material. Shortt has noted the presence of inclusion bodies simulating Negri bodies in salivary glands in dogs after an injection of pilocarpine.

Pappenheimer and Hawthorne have observed cytoplasmic inclusions in cells of the liver in human beings and in monkeys. They were found in foetal cells also. They were not noted in the livers of rabbits, dogs, cats, rats and mice. When they were found, no association with any disease was noted or with any type of liver lesion. As the authors point out, if we accept that inclusions are the results of virus activity, we have also to assume that a large proportion of human beings harbour a non-pathogenic virus, and that the virus is transmitted to the embryo. It is obvious that such findings have to be interpreted with great caution.

Recovery from an infection is associated with the development of immunity which, in the majority of virus diseases, is usually permanent. Only in some cases, as in influenza, herpes and foot and mouth disease, it is transient. To this extent, virus diseases, as a class, may be said to differ from bacterial diseases in which the immunity is usually of a transient character except, perhaps, in typhoid and in diphtheria. This distinction is not, however, intended to convey that the essential immunity phenomena differ radically in the two classes of diseases. As Bedson has recently pointed out 'the problem of immunity to any given virus or bacterium is a problem to itself; each has its special features and peculiarities.'

In discussing the question of immunity in virus diseases, one would like, first of all, to ascertain whether, in natural or experimental infections, antibodies, such as are usually met with in bacterial infections are also present in the serum after recovery from virus diseases. That such is the case has now been definitely proved. Earlier workers used for the demonstration of such antibodies crude suspensions of viruses. Since the demonstration that elementary bodies are the actual virus agents, a technique has been devised to obtain them in pure suspensions so that serological reactions can now be performed with considerable accuracy. The crude suspensions of a virus is first lightly centrifugalized to remove coarse material and the supernatant fluid passed through a Berkefeld V filter. The filtrate is then centrifugalized at a high speed—at about 15,000 r.p.m. for about an hour. The supernatant fluid is discarded and the deposit, which can be purified by washing, if necessary, is re-suspended either in Tyrode or Ringer solution. In most instances, such a suspension is found to contain most of the virus units and this can be demonstrated by suitable infectivity tests. By the use of such suspensions it has now been demonstrated that agglutinins are present in such virus infections as vaccinia, variola, fowl-pox, varicella, herpes, etc. It has been found that agglutinins make their appearance on the 5th or 6th day after an intradermal injection of the virus, rise to a maximum titre and then slowly decline. Immunological relationships between related viruses have also been determined by the application of the agglutination absorption technique. Common agglutinins for variola and its variant—alastrim—have thus been determined. That a common antigen exists between variola and vaccinia viruses has also been demonstrated. Ledingham has found that rabbits inoculated with fibroma virus develop agglutinins for myxoma, but not so readily for the fibroma virus itself, unless myxoma virus is also inoculated when agglutinins appear for both.

Complement-fixing antibodies in some virus infections such as influenza and flocculation antibodies in others such as vaccinia and variola have also been demonstrated. The latter reaction had been particularly developed by Tulloch and Craigie for the diagnosis of smallpox. Such flocculation was not noted when the anti-vaccinia serum was mixed with an antigen prepared from varicella crusts. The antigenic structure of vaccinia virus has been particularly studied by Craigie and his collaborators. Two types of antigens have been shown to exist in suspensions of elementary bodies of vaccinia. One is thermostable—the S type of antigen, and the other thermolabile—the L type antigen, both of which take part in serological reactions.

Chen, and also Craigie and Wishart, have isolated a specific soluble substance by extraction of elementary bodies of vaccinia. This substance behaves as an antigen, as determined by precipitin and complement-fixation reactions with anti-vaccinial serum. It is probably this substance which is responsible for the flocculation reaction of Tulloch and Craigie just described. It is also interesting to note that the specific soluble substance, like the elementary bodies, has two antigenic components—the heat stable and the heat labile, which give rise to the corresponding antibodies. It has also to be stated that elementary bodies produce rapidly all the antibodies including the neutralizing antibody, but the specific soluble substance produces them more slowly and with the exception of the neutralizing antibody, which seldom appears to any appreciable extent.

The finding is important and brings to our mind the significance of a similar substance isolated from pneumococci. Such an antigenic analysis has been attempted with other viruses also, e.g. in the case of influenza virus by Hoyle and Fairbrother.

Apart from the antibodies discussed above, antiviral or neutralizing antibodies are also found in viral infections. The existence of such antibodies was first noted by Strenberg in 1892 in vaccinial infections. Since then the neutralizing antibody has been demonstrated in almost all the virus diseases, and the available experimental evidence indicates that this antibody plays the major rôle in the mechanism of immunity in virus diseases. There is no general agreement, however, on the precise mode of action of this antibody. The question of the union of the antibody with the antigen is much debated. Working with vaccinia, Andrews has shown that when the virus and its antibody were mixed in suitable proportions, and the mixture inoculated into the skin of a rabbit, no lesions appeared in the animal. When this neutral mixture was then diluted and a small fraction of the diluted mixture inoculated into a rabbit, typical vaccinal lesions appeared at the inoculated sites. The neutral mixture was reactivated by the simple process of dilution. Similar observations were recorded with other viruses, e.g. herpes, poliomyelitis and fowl plague. In this respect the results correspond with similar reactions noted with the Toxin and antitoxin mixtures. Andrews further demonstrated that if the neutral mixture was left sufficiently long—a few days in the case of vaccinia—a stable union occurred between the antigen and the antibody, which could not be distributed by dilution. On the other hand, Olitsky and Long were able to recover almost all the virus from a neutral mixture kept in the cold for one month by subjecting it to cataphoresis.

Sabin has investigated the problem using ultra-centrifugation methods. Working with a neuro-testicular strain of vaccinia virus, he prepared the virus suspension by passing minced infected testes through a Berkefeld V filter. Immune serum was added in excess and the mixtures incubated for one, seven and fourteen days. They were then centrifugalized at 14,000 r.p.m. for 3 hours. He found that the sediments had retained their infectivity in practically undiminished concentration. In the filtrates, the antibody also remained in the same concentration as before. He concluded that under the conditions of the experiment, there was no union at all between the virus and the antibodies in the immune serum. Similar results were obtained with Pseudo rabies and B. virus mixtures. It must be remembered, in interpreting these results, that rabbits were used as test animals to determine the infectivity of mixture, using ten-fold dilutions. Keogh has rightly pointed out that by this method it would not be possible to distinguish with accuracy one virus suspension from another 10 times as strong. To obviate this difficulty, he repeated the experiments but tested the mixtures by inoculating them on the chorio-allantoic membrane of the chick embryo. By counting the number of 'pocks' on the membrane a more accurate idea was obtained regarding the number of viable units present in the mixture. He was able to show by this technique that the immune serum did combine with the virus and that the union was reversible by dilution.

That such a dissociation of the antigen antibody complex also occurs *in vivo*, was shown by Andrews and Todd and by Craigie and Tulloch. These experiments raised, however, another important problem, viz. the route of infection.

Andrews showed that the neutral mixtures, innocuous when injected into the skin, produced specific lesions when inoculated into the testes, brain, or even the general circulation. Todd found that fowl plague mixtures, neutral by the intramuscular route, were pathogenic by the intravenous route. Craigie and Tulloch centrifugalized the vaccinia neutral mixtures and suspended the deposit, after drying, in saline. The saline suspension was nonpathogenic by the subcutaneous route but produced lesions by intra-testicular inoculation. Since the main attack of vaccinia virus is on the reticulo-endothelial system Ledingbam has suggested that the difference in the amount of such tissue present at the site of inoculation probably explains these results.

The question now arises how does the antiviral antibody act *in vivo*? What part do leucocytes play in the process? These are important questions as they have a bearing on the possible treatment of virus diseases with immune sera. It is not possible to give a direct answer to these questions. Two factors have to be borne in mind in this connection. The antibody, even though it unites with the antigen, does not kill it. The dissociation results recorded above prove this. Secondly the action of viruses in most cases is explosive. The antibody, if it is to act at all, must do so rapidly.

It has been established that an antivaccinia serum, suitably prepared and administered in suitable doses to experimental animals either subcutaneously or intravenously, confers some degree of protection against a subsequent inoculation of vaccinia virus. Andrews has investigated the time factor concerned in such reactions. One group of rabbits received antivaccinial serum 24 hours before they were inoculated with the virus. The second group received the serum and the virus simultaneously, while the third group received the serum 24 to 48 hours after the virus. It was observed that the serum gave protection only when it was given at least 5 minutes ahead of the virus. After the simultaneous inoculation of virus and anti-serum the development of the local lesion was practically unaffected.

Probably the dose of the serum administered may have some bearing on the question of protection, for, according to Craigie and Tulloch, serum in doses of 2 c.c. per kilo of body weight adminstered one hour later, does confer some protection in rabbits. However, as they point out, 'the method of testing the degree of protection is probably very artificial, in that the virus is introduced into the skin in a highly concentrated form and its introduction is accompanied by severe trauma'.

I have repeated these experiments in the King Institute, using monkeys as test animals, as the course of vaccinia in them is of a much longer duration than it is in rabbits. The vaccinia immune serum was obtained from hyper-immunized buffaloes and both vaccinia and variola viruses were used in the experiments. It was found that when the serum was administered along with the virus, a considerable degree of protection was obtained against both viruses. When the serum was given at varying intervals after vaccination, no protection was demonstrable against vaccinia. On the other hand, the serum gave considerable protection against variola virus even though it was administered 4 hours after the virus had been introduced by scarification.

The same phenomenon has been observed in tissue cultures. Virus III, and Herpes virus give rise in tissue cultures to intranuclear inclusions. These are not formed when the corresponding immune serum is added to the culture simultaneously with the virus. Added after the virus, the immune serum exerts no specific effect. These experiments also suggest that leucocytes play no part in augmenting the action of the immune body for leucocytes in such cultures are normally scanty and immobile. A few workers have, however, doubted this.

The question is as to how, under the conditions of these experiments, does the antibody act in exerting its protecting influence ? It would appear from the foregoing that once the virus enters the cell the antibody is powerless to neutralize it. We have also seen in the *in vitro* experiments, that it does not kill the virus. Is it likely, then, that the antibody when it is introduced in advance of the virus alters the tissues cells in such a way that the virus finds it difficult to gain a foot-hold ? Sabin's experiments seem to point in that direction. Broadly his experimental evidence can be summarized in the following way :—

In culture with normal serum, the virus gets fixed to the tissues and multiplies. With immune serum union with the tissues occurs, but, though the virus is alive, it neither multiplies nor forms any inclusions. Susceptible tissues incubated with immune serum and subsequently washed to remove traces of the latter, are found refractory to infection when the virus is added to them. The refractory state is, however, reversible, for the tissues are rendered susceptible by thorough washing. Sabin concludes, that the immunity to the virus is intimately bound up with the cell and protective substances act on the tissues rendering them refractory to infection. We must await further confirmation of these results.

Salaman has elaborated this point of view further as a result of his study of vaccinia virus cultivated in slide cultures of rabbit's cornea, i.e. the technique of Bland and Rabinow. He regards that the antisera act on the cell-surface, preventing the entry of the virus into the cell, the antibody attaching itself either to the virus or the cell-surface, or to both.

This problem has been recently investigated by Goodpasture and Anderson by the use of a new technique, namely, grafting of normal and immune chicken skin over the chorio-allantoic membrane of developing chick embryos, and then inoculating the grafts with fowl-pox virus. He states 'the cutaneous epithelium which is completely refractory to fowl-pox while part of the immune host, becomes quite as susceptible as the epithelium of normal chick skin when grafted on the chorio-allantois. Humoral antibodies, therefore, are the most potent agents in the acquired immunity of cutaneous epithelium to fowl-pox infection.

From the experimental evidence so far recorded, it is reasonable to conclude that the neutralizing antibody plays an important part in the mechanism of immunity. Failure to demonstrate this antibody in some viral infections has led some workers to postulate that there might be another process at work, whereby tissue cells become resistant, without the intervention of the antibody—the so-called *tissue* immunity.

For instance, in guinea-pigs resistant to infection with foot and mouth disease virus, antibodies are not demonstrable in blood. There are not many instances of this type however. Besides, the question is intimately connected with the experimental methods adopted. Rabbits resistant to herpes virus do not show the antibody in blood, but guinea-pigs do. Perhaps the technique used in demonstrating the antibody may not be infallible. As Bedson has shown, 2·0 c.c. of immune serum passively protects the guinea-pig against herpes. To demonstrate this amount of antibody, when it has reached the circulation, would not be an easy matter.

There is some evidence, however, that in plant viruses a sort of tissue immunity does exist and humoral antibodies do not play a part. Salaman has shown that there are two strains of potato X virus—one nonpathogenic and the other capable of producing disease. Infection with the former renders the tissues insusceptible to the invasion of the latter

Findlay has observed the same phenomenon with yellow fever and Rift Valley fever viruses. Pantropic yellow fever virus is fatal to monkeys. If they are infected with both the pantropic and neurotropic viruses, they survive. Even when monkeys are infected with pantropic virus first and within a few hours with the neurotropic virus, there is some evidence of protection. Findlay regards this as an 'interference phenomenon'. There was no evidence to show that antibodies had been produced so rapidly that they could have explained these results. This effect has been noted also to some extent with Lymphocytic Choriomeningitis and Poliomyelitis viruses, and with Fibroma and Herper III viruses. Some recent observations made by me at the King Institute seem to suggest that the same phenomenon probably occurs with Vaccinia and Rinderpest viruses. The matter is at present under investigation. The phenomenon has its counterpart in bacteriophagy. A bacterial culture subjected to the action of a weak bacteriophage, which does not produce lysis, is subsequently found to be resistant to the action of a virulent strain of the same bacteriophage. The question of the action of any antibody does not arise in this case. Findlay, therefore, suggested that cells occupied by actively multiplying virus could not be re-infected with the other virus. This raises the point for which there is ample experimental evidence, that immunity in viruses is due to the persistence of infection in resistant hosts.

I shall first summarize the experimental evidence bearing on this point. Persistence of virus after recovery is shown to occur in a number of virus infections. A guinea-pig infected with salivary gland disease becomes immune but the virus can still be recovered at any time from its salivary glands. Rivers has shown that Brown-Pearse Carcinoma of rabbits is invariably accompanied by virus III and the rabbits show neutralizing antibodies against virus III. Virus III can be isolated from the metastases of the tumour even though the rabbits are found to be immune to virus III infection. The virus of laryngotracheitis can be isolated from immune birds, and the virus of encephalomyelitis from mice one year after recovery of the animals. The same thing is observed in Psittacosis, both in animals recovering from an experimental infection and those recovering from a natural infection. What is more, if mice are first immunized with formal-killed Psittacosis vaccine, and a dose of active virus, about 1,000 M.L.D., injected later, apparently an inapparent infection is set up, and the virus can be isolated after 9 months. Persistence of infection has also been shown to occur in Poliomyelitis and in vaccinia. Some experiments which I conducted in the King Institute years ago seem to show that vaccinia virus could be isolated from immune rabbits 40 to 50 days after infection.

It was possible to revaccinate such animals with suitable doses after that period. By employing the cataphoresis technique to separate the virus from the tissues, Olitsky and Long were able to recover the virus after 133 days after infection.

Peyton Rous and his collaborators have reported some tissue culture experiments which throw light on the factors considered in the persistence of the virus in the immune host. Individual cells, which get rounded off after some time in cultures, were selected for the study. In mixtures of such cells and vaccinia virus it was found that the virus gets rapidly fixed to the cells, irrespective of whether such cells were alive or had been killed by heat or ultraviolet light. The union was firm. If the neutralizing antibody was added to such cells, the virus was not killed when the cells were alive; if the cells were dead, the virus was destroyed. The protection afforded by living cells to the virus contained in them is thus well exemplified.

The phenomenon of persistence of infection is not a monopoly of viruses, however. It is particularly noted in protozoal infections. It has been seen to occur in nonpathogenic trypanosomiasis, kala-azar, malaria and also in some bacterial and spirochaetal diseases.

I have so far attempted to present in detail the experimental evidence which has a direct bearing on some aspects of viral immunity. The survey has only revealed the great complexity of the problem. This is not surprising in view of the intimate type of parasitism exhibited by viruses. We have no adequate knowledge of the vital processes involved when a virus invades the susceptible cells. This is, of course, true of other infections also. Indeed, it would appear that the defence mechanism of the infected host is the same whether the infective agent is a bacterium, a virus, or a protozoal parasite. Agglutinins, precipitins and neutralizing antibodies are produced much in the same way as in bacterial diseaes. If the virus is introduced in the fluids of the host, these antibodies are produced and the virus destroyed. The only difference is in the action of the neutralizing antibody. We may assume that when the virus is in the body fluids the antibody acts much the same way as in bacterial infections, viz. it unites with the virus and renders it susceptible to phagocytosis. Once the virus enters the susceptible cell, the antibody has no direct action on the virus. When the cell divides the virus will pass into daughter cells and, as long as the process is kept up, it will maintain a latent infection or persistence of infection. If the cell is destroyed, the virus will be brought into contact with the antibody in the surrounding fluid and will then be destroyed. More antibody is also produced. If such is the course of events, it would be interesting to speculate what would happen in the case of neurotropic viruses. As Goodpasture has stated, if a virus can utilize the living cell for its reproduction, there is nothing to prevent it making its way from cell to cell along the connected cytoplasmic processes and thus reaching its central termination. During its sojourn, it will not come into contact with the antibody at all. The failure of immune sera in such infections as polio-myelitis is thus explained.

We have so far dealt with the mechanism of immunity which follows as a result of infection. Jungeblut has recently drawn attention to another defence mechanism which is dependent on environmental factors such as heredity, sex locality, etc. Working with the virus of poliomyalitis he found that the virus was inactivated by extracts of adrenal gland. Further investigation determined that Vitamin C, an important constituent of the adrenal gland, possessed this viricidal property. The therapeutic value of Vitamin C was then investigated. Monkeys infected intracerebrally with the virus were treated by daily injections of Vitamin C. When ascorbic acid was used, the results were not encouraging, but the administration of natural Vitamin C gave promising results, and six times as many treated animals escaped paralysis as compared with the corresponding controls. How does the Vitamin C act? Is it through direct action on the virus? Or does it act by stimulating some enzyme systems and thus bringing about a change in the cell permeability? Resistance to poliomyelitis may be considered as of two types. The first is due to recovery after infection or to repeated contact with the active agent which produces only subclinical infection and consequent immunity. The second factor, which Jungeblut considers more important, is based on the assumption that poliomyelitis is a developmental disorder of youth, and protection against it is chiefly due to physiological factors. In discussing various reasons for this belief, he draws attention to direct experimental evidence which indicates that poliocidal substances found in normal human and animal tissues, serum, tears or other body fluids, are probably not of antibody character but resemble agents of vitamin-like or hormonal nature.

I would like to refer you to the original communication of Jungeblut for the further development of this hypothesis. As he has pointed out himself some observations are not in accord with his conception. For instance, Vitamin C is said to diminish with the advance of age, but the reverse is the case with the neutralizing antibodies. Vitamin C deficient guinea-pigs are refractory to infection with poliomyelitis. The problem is interesting and opens a new field in virus prophylaxis. It is also related to the origin and significance of normal antibodies.

It would be proper, I think, now to discuss how the knowledge thus gained has been applied in the prevention of virus diseases in man. On the analogy of bacterial diseases, it is not surprising that attempts should have been made to use killed virus vaccines as a prophylactic measure. In discussing the efficacy of killed viruses several factors have to be borne in mind. It is not enough merely to show that under experimental conditions killed vaccines give rise to antibodies and confer protection. The dose of the killed vaccine required and the duration of immunity engendered by it. are the essential criteria. Judging by these, it does not appear that dead vaccines have so far proved their utility, and the consensus of opinion amongst virus workers seems to be that the use of attenuated live vaccines is the method of choice in the prevention of virus diseases.

It must, however, be stated that most of the experimental work on this problem had been done with heat killed vaccines. With the demonstration that formalin preserved the antigenic components better, as was noted in the case of bacterial vaccines and in the preparation of diphtheria toxoid, the efficacy of virus vaccines inactivated by formalin was further investigated. Bedson demonstrated that foot and mouth disease virus inactivated by low concentrations of formalin, produced immunity in experimental animals. Identical results have been obtained with the viruses of herpes, psittacosis, Rift Valley fever, canine distemper and, recently, with influenza virus. Indeed, Fairbrother and Hoyle have shown that elementary body suspensions of influenza virus inactivated by heat at 57°C. were as potent antigenically as formalinized suspensions. The importance of working with purified vaccines has thus been demonstrated.

The chief difficulty in accepting the efficacy of formalinized vaccines seems to be the inability to demonstrate conclusively that the formalin treatment completely inactivates the virus. As in anatoxin preparation. it is necessary to work within a very narrow range of formalin concentration. Too strong a concentration will destroy the antigenic property, while weak concentrations may not fully inactivate the viruses. Of course, the inactivity of formalinized vaccines has been demonstrated by their massive injection into experimental animals which subsequently failed to show signs of infection.

Dead vaccines are now being tried in the prevention of poliomyelitis in America. Two vaccines are in use. That used by Brodie and Park is inactivated by formalin. The second vaccine which is being tried is prepared by Kolmer. The source of the virus is the spinal cord of a monkey infected with the poliomyelitis virus. The virus is inactivated by the addition of 2% solution of sodium ricinoleate with 1 : 40,000 phenyl mercuric nitrate.

It is too early to judge the results of this method of vaccination, as children have to be observed for a long period of time.

Since the discovery of Influenza 'A' virus, as the causative agent in epidemic influenza by Laidlaw and others in 1933, attempts have been made to study the protective value of the formalinized influenza vaccine prepared from infected ferret lungs. It appears from the limited trials thus far made, that the protection conferred is not adequate. Further advance in this respect seems possible now owing to the researches of Horsfall and his collaborators. I have already referred to the so-called interference phenomenon with viruses. However, with the simultaneous inoculation in ferrets of both the influenza and distemper viruses, the results were entirely different. In this case, both the viruses produced infection which ran concurrently. It was, however, noted that in ferrets thus inoculated, the influenza virus persisted in the lungs much longer than was the case when only the influenza virus was given. This effect is called 'Synergism' by Horsfall. The complex vaccine prepared from ferret's lungs apparently gives better protection in animals. This is not related necessarily to the higher virus content of the lungs, but as Horsfall suggests, probably to some qualitative change in the virus. Field trials on a limited scale conducted by Martin and Eaton tend to confirm the above results and the protection conferred was similar as when live influenza vaccine was used.

The only dead vaccine which has been used extensively in the fields is, I believe, the rabies vaccine. Shortt and his collaborators have investigated the immunizing value of different strains of rabies virus inactivated by different ways. Formalin or carbolic acid showed no special advantages one over the other as a preservative. They also investigated other methods of immunization in rabies. They concluded as follows :—

Treatment by one dose of a combination of fresh living fixed virus and antirabic serum has been shown to have a considerable immunizing value ; although the main effect appears to have been exerted by the live virus, the serum being used merely to render the use of the live virus more safe. The use of fresh living fixed virus as an adjuvant to treatment with carbolized dead virus has been shown to be the most effective method yet tried for the immunization of dogs and therefore of other animals also. They suggest that future lines of advance towards the most efficacious means of producing a solid immunity against rabies will be along the path of utilization of antirabic serum and fresh live fixed virus, possibly combined with the use of dead vaccine.

The methods envisaged in the case of rabies have already been utilized in the case of yellow fever, for, in this disease, only living vaccines are found to be of any value. The yellow fever virus has two predominant affinities, the viserotropic and the neurotropic. The alteration in pathogenicity which ensues on prolonged cultivation in the presence of embryonic cells is now fairly well established. That procedure has rendered the use of live vaccine safe for human immunization. Attempts at human immunization date back to 1930, when Theiler demonstrated that viscerotropic virus, rendered neurotropic by passage through mice, lost its virulence, without altering its immunizing power. The neurotropic vaccines were first tried by Sawyer, Kitchen and Lloyd in America and Sellards and Laigret in Africa. Sawyer used the virus fixed for mice mixed with yellow fever immune serum, while Laigret used pure neurotropic virus attenuated by storage in glycerine. One possible objection to the use of neurotropic virus might be mentioned. The virus circulates in the blood for some days after inoculation and, theoretically at least, it would be possible for yellow fever to spread if such persons were bitten by the mosquito vector. Actually no such infection has resulted however, even though the vaccine has been extensively used both in America and Africa. The virus apparently loses its infectivity for the mosquito. That such vaccines confer protection in human beings was determined by what is known now as the mouse protection test developed by Sawyer and Lloyd. This test demonstrates the presence of circulating antibodies in the serum of vaccinated individuals.

As a rule, no untoward results have been noticed with the use of such vaccines. The antibody titre, however, diminishes gradually and re-vaccination becomes necessary after two years.

It was found later, however, that prolonged serial passages in tissue culture had so altered the virulence of the virus, that it was possible to use the virus alone for immunization without the addition of immune serum. Such vaccines are now being extensively tried in South America. The results are promising.

Findlay in England advocates the use of the pantropic virus. This is now so attenuated in virulence by tissue culture passages that it can be used without the addition of immune serum. This method is claimed to be as efficient as others used in America.

I may mention here that the mouse protection test has been utilized to map out areas of yellow fever prevalence. The test is positive where yellow fever is endemic, but negative in areas where yellow fever has not existed within recent times. Sera examined from India were found to be negative. I need hardly stress the importance of these investigations to India.

Recently we have tried the use of Live vaccine in the prophylaxis of Sand Fly Fever. The vaccine was prepared by growing the virus on the chorio-allantoic membrane of the chick embryo. The inoculated volunteers showed no marked general or local reactions. The virus could be demonstrated in the circulating blood on the 5th day, and neutralizing antibodies up to 35 days. Attempts were then made to transmit the infection by inoculating them with infective serum from cases of Sand Fly Fever. The number of volunteers available for the study were, however, too few in number, and no definite conclusions could be drawn as to the efficacy of the vaccine used.

I have attempted to give you a brief summary of the present position of immunity in virus diseases. The subject is a complex one. The evidence accumulated so far does not permit us to postulate any comprehensive working hypothesis. It is probable that all the factors discussed heretofore, viz. circulating antibodies, tissue immunity, persistence of virus after infection, etc., play a part in bringing about that solid immunity after infection which is such a marked feature of virus diseases.

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SECTION OF AGRICULTURE

President :—NAZIR AHMAD, O.B.E., PH.D., F.INST.P., J.P., F.N.I.

Presidential Address

(*Delivered on Jan. 3, 1942*)

SOME TEXTILE FIBRES OF INDIA

GENTLEMEN,

I am deeply sensible of the honour you have conferred upon me by electing me as President of the Section of Agriculture at the 29th Session of the Indian Science Congress which is being held at Baroda. It is a matter of supreme gratification for a research worker when his humble efforts in the cause of scientific progress are appreciated by his colleagues and co-workers; and I am doubly conscious of the honour you have done me, because I am not an 'agriculturist' in the strict sense of the word. Trained as a physicist I have had the privilege, for the last 12 years, of occupying a position on a bridge which connects one of India's premier industries with one of her principal crops. The duties of my post have necessitated that I should, on the one hand, collaborate with agricultural officers in their efforts to improve the quality of India's cottons by furnishing them with technological data on their new strains and selections, and on the other hand that I should carry out such investigations as would help in a better understanding of the properties of these cottons and their greater industrial consumption. I feel, therefore, that in electing me to preside over the deliberations of this Section, its members have not only acknowledged implicitly the great principle of the fundamental unity of Science beneath its apparent diversity, but have also set their seal of recognition and approval on the intimate connection which should exist, to their mutual advantage, between India's industry and agriculture. We have been accustomed for such a long time to look upon India as a producer of raw materials that we are sometimes inclined to forget the important place which industrial development occupies in the national economy of all civilized and advanced countries of the world. It constitutes the quickest means of augmenting the national wealth of a country, and provides a powerful safeguard for ensuring that the cultivators get the best monetary return for their labours in these days of trade restrictions, quotas and tariff walls. It would, therefore, be a happy augury for the future if those who are primarily engaged in agriculture widened their interest to see that the commodities, which they have helped to improve, are used for the manufacture *in the country* of a thousand and one articles required by its people.

In view of what I have said above it seems particularly appropriate that by a set of unforeseen circumstances the meetings of this Section are being held at Baroda, where a wise and far-sighted administration has nourished both industry and agriculture. The efforts of the State in promoting the cultivation of improved varieties of cotton, ground-nut, rice, etc., are well known to you. Nearly 30 per cent of the area, or 800,000 acres, is under cotton, producing a crop of over $2\frac{1}{4}$ lakhs of bales per annum, which includes the improved varieties of 1027 A.L.F., B.D. 8, B. 9 and Wagad 8. But what is perhaps not generally known is the fact that the State can boast of 16 cotton mills having 3,32,000 spindles and 7,110 looms in which over 20,000 hands are employed. Besides this large textile industry, it has a China Clay Works at Ransipur, a woodwork factory for making bobbins, shuttles, etc., at Navsari, a sulphuric acid factory at Petlad, while a textile soap factory was recently in the course of erection. The Alembic Chemical Works situated at Baroda are the largest of its kind in India, while the enterprising House of Tatas have recently decided to establish a large factory for the manufacture of heavy chemicals at Mithapur. This happy combination of agricultural improvement and industrial development, you will agree, is a praiseworthy achievment.

I have selected the title 'Some Textile Fibres of India' as the subject of my address, but before I speak on this subject, I wish to offer a few explanatory remarks. In the first place I have been more intimately connected with cotton than with any other fibre during the last several years, and it is, therefore, only natural that cotton should occupy the major portion of my address, though I shall deal with some of the other more important fibres as well. Secondly, I do not propose to trace the historical development of the work on fibres in the Government farms, laboratories and factories. That would indeed be an extremely interesting but Herculean task, and its performance here might easily overtax the limits of your patience. I would rather content myself with the present day position regarding these fibres, with a few suggestions on the lines along which intensification of work or exploitation of the available results is indicated in the near future. Thirdly, I do not propose to confine my remarks to the purely scientific aspects of the subject; but, with your permission, will also touch upon, wherever necessary, the industrial and economic aspects, as these often have far-reaching effects on the utilization of scientific results. Life nowadays is a complex affair in all but the most primitive communities; it is rather like a fabric in which the strands of agriculture, trade, industry, science, arts, administration, etc., have been inter-woven into a complicated pattern, and each strand is subject to the forces set up by the others. In such a complicated world the kind of expert who continues to learn more and more about less and less is apt to become increasingly effete as the part played by scientific research and technical advance in shaping the economic, industrial and even social life of a country assumes greater and greater importance. In my humble opinion the scientist, whose training teaches him to avoid dogma, verify theories and think in a rational way, has been content too long to look passively on a world which he has helped materially to fashion and to mould, and I feel that he should now change his outlook and take a more unified and integrated view of the present day world, so that the results of his investigations are not vitiated by forces which he does not care to understand and over which he exercises no control, but are utilized to the fullest possible extent in the service of mankind.

With these preliminary remarks, I shall now turn to the first textile fibre, namely cotton, which I propose to consider in this address.

Cotton

India's association with cotton goes back to dim antiquity and forms one of the bright chapters of her long and glorious history. When the excavations at Mohinja-da-ro made the dead give up their long-buried secrets, some pieces of silver were found wrapped up in a fabric which the action of silver had helped to preserve during all these years. This fabric was examined at the Technological Laboratory, and was found to be made entirely from cotton, the counts of yarns and the structure of cloth both indicating the attainment of a high degree of skill in the arts of spinning and weaving in those distant times. This discovery proved conclusively that as early as 3000 B.C. the Indians had acclimatized some of the wild cottons, and grown them along the banks of the Indus, and that they had mastered the arts of spinning these short fibres into yarn. This achievement was much more remarkable than that of the ancient Egyptians who were then experimenting with the comparatively longer fibres of flax, which is much easier to spin with hand than cotton. From that time onwards the cultivation of cotton, its use for the manufacture of piecegoods and the dyeing and finishing of these fabrics made a steady progress, until in the Middle Ages the fame of India's cotton materials spread far and wide, and she did a roaring trade in these fabrics not only with the adjoining countries but also with far distant lands. The softness, fineness and beauty of the Dacca muslins have become legendary, and their names, such as Shabnam

(Dew), Ab-i-Ravan (Flowing water) which have come down to us bear testimony to the artistic taste of the people as well as to their truly remarkable skill in making these wonderful garments. They have also a scientific interest for us inasmuch as they show that, unaided by complicated machinery but supported by public patronage, the artisans were able to manufacture these fabrics only from the Indian Cottons, as it is not reported that any foreign cotton of a superior kind was imported for this purpose. Today, with all the advantages of modern machinery, India has to import hundreds of thousands of bales of foreign cotton every year for the manufacture of fine *saris*, shirtings, suitings, etc., which are required by her well-to-do classes.

These halcyon days were followed by a period of decline during which India's textile industry, neglected by the East India Company and discriminated against by the foreign governments, who were anxious to develop their own industries, steadily lost ground. As one of the consequences of this decline, the quality of her cottons deteriorated rapidly by the mixing of seeds, loss of pure varieties and absence of any breeding work—an example of the keen influence of industry on agriculture to which I have already drawn your attention. This period of decay ended approximately in the seventies of the last century when the inception of the Indian textile industry at Bombay and the American Civil War, which for nearly four years cut off the American supplies, forced attention to India's cottons. The work of improving these cottons was seriously taken in hand, and though the end of the American Civil War re-opened the American supplies, the rapid increase in the number of cotton mills in India in the subsequent years provided the necessary stimulus. By 1876, forty seven cotton mills had been erected, in 1900 their number stood at 193 while in 1925 it had mounted to 337. During this period a large number of American and Egyptian varieties were tried in different parts of India, and though the actual success was not so great as originally anticipated, a great deal of the exploratory ground had been covered, and the way had been cleared up for further progress. As a result of this work, at least three American varieties, namely 4F in the Punjab, Dharwar—American in Bombay Presidency and Cambodia in Madras Presidency, had been found suitable and their cultivation had spread over fairly large areas.

The Indian Central Cotton Committee was constituted in 1920, and at once began to co-ordinate, direct and expand work on cotton on an all-India scale. Its members included Directors of Agriculture of the chief cotton growing provinces and states, representatives of the growers, merchants and industrialists, cotton breeders and other research workers engaged on cotton problems. It financed schemes for botanical, physiological, agronomical and seed propagation work at suitable centres, and at its biennial meetings, where every important interest was represented, examined the progress of these schemes, and made suggestions for directing it into useful channels. It maintains a Technological Laboratory at Bombay where the breeders can get their new strains tested and compared to the local cottons, and a Genetical Section at Indore where fundamental work is in progress. It has also been responsible for the introduction of healthy legislation in several provinces and states to prevent, or at least minimize such abuses as adulteration of varieties, watering of cotton, mixing of seeds, etc. Its efforts have included the introduction of several improved varieties in different parts of India, and investigation of numerous problems relating to failure of the cotton crop, its diseases and pests, rotation and inter-cultivation with other crops, frequency and amount of irrigation, etc. As a result of these co-ordinated efforts, it may be stated definitely that the quality of the crop has improved appreciably in many parts of India in a short period of 20 years. This improvement has not only been admitted by several observers who have carefully studied the statistics relating to Indian cottons, but is also indicated by the fact that during the last few years committees on the model of the Indian Central Cotton Committee have been set up for coffee, jute and tea, and are functioning quite successfully.

I shall now make a rapid survey of the main problems encountered, measures adopted and success achieved in the various provinces. Beginning with the northern-most province where cotton is grown in large quantities, namely the Punjab, it is interesting to note that it was one of the first provinces in which the cultivation of American cottons from imported seed was tried. After many attempts a variety known as P.A. 4F, which has a staple of about $\frac{7}{8}''$ and is suitable for spinning up to 20's warp or 24's weft, proved highly successful, and is now grown to the extent of about 500,000 bales per annum. This cotton, though satisfactory from many points of view has, in the past, suffered severely from a disease locally known as *tirak*, which causes bad opening of the bolls and results in partial failure of the crop. A very considerable amount of work has been done at Lyallpur to find out the cause of this disease, and it now appears highly probable that it is due to two sets of soil conditions, namely, (1) deficiency of nitrogen, and (2) salinity in sub-soils. If this explanation is correct, then it follows that irrigation or treatment of soil with suitable fertilizers or manures at the appropriate time may provide the remedy for this disease which in the past has inflicted so much loss upon the cultivators. The happy combination of a temperate climate and an extensive system of canal irrigation, which ensures a regular supply of water, made this province eminently suited for the cultivation of American types, and further efforts resulted in the introduction of a still longer type known as P.A. 289F, which possesses a staple of nearly 1″ and is suitable for spinning up to 30's warp or 40's weft. This cotton, which represented a notable improvement upon P.A. 4F, satisfied, to some extent, India's growing requirements in respect of staple cottons; but from the agriculturist's point of view it suffers from three defects, namely, (*a*) low ginning percentage, (*b*) liability to suffer from frost, and (*c*) susceptibility to jassid attack. Accordingly, recent work in the Punjab has been concentrated upon the evolution of varieties free from these defects, and it is gratifying to note that a fair measure of success has already been achieved in this direction. A further selection from P.A. 289F evolved at Lyallpur, is an early maturing strain, and has further the advantage of being a better resistant to drought and jassid attack. Similarly, another selection made at Khanewal and known as 289F/K25 has a higher ginning percentage, though its limits of variation are rather wide. It is estimated that the area under P.A. 289F and its selections already amounts to over **275,000** acres giving an annual crop of about **166,000** bales. Work is being continued to evolve still better Punjab-American strains.

While work has been going on on the American cottons in the Punjab, the *desi* cottons of the province have not been neglected. The first *desi* strain to be evolved was 16 *Mollisoni* in 1929, which was replaced by 15 *Mollisoni* in 1930, which in its turn was replaced by 39 *Mollisoni* in 1934. The latter cotton has gained much popularity and is grown over an area of 4,35,000 acres. But the most notable achievement in this direction has been a cross between 39 *Mollisoni* and the Chinese *Million Dollar*, which has been named *Jubilee* cotton and is spreading rapidly in certain parts of the Punjab.

One of the most troublesome problems in the Punjab has been the mixing of cottons, the adulteration of the superior with the inferior varieties. A great deal of time has been spent in the endeavour to locate the origin of this evil, nevertheless it has persisted and has neutralized to some extent the good work of the breeder. It is true that its complete eradication is not an easy matter, but it is clearly a case where the full value of the scientific work is not being realized owing to human cupidity and a desire to make quick profits regardless of the larger considerations. It, therefore, calls for strong measures, even though these may not be liked by a certain class of people, and some difficulties may be encountered in enforcing them. The great Napolean's dictum that the word difficult is found only in the dictionary of fools may savour too much of the superman, but difficulties should not be allowed to stand in the way of our reaping the full benefit of scientific work.

Turning now to the contiguous province of Sind, which rather resembles the Punjab in possessing an excellent system of canal irrigation, it is interesting to note that the two improved

American varieties, namely Sind Sudhar and 4F-98, which have found favour with the cultivators, are selections from the Punjab cottons 289F and 4F. Sind Sudhar has a staple of full 1" and is suitable for spinning up to 36's counts, while 4F-98 with a staple of about 29/32" is good for spinning 30's yarns. The area under their cultivation has already increased to over 3 *lakhs* of acres, which represents nearly one-third of the total area under cotton in 1939-40. The improved type from the Sind *desi* cotton is known as Sind N.R.; which is grown over an area of nearly 2¼ *lakhs* of acres. It is noteworthy that the Sind *desi* cotton has a rough feel, which makes it specially suitable for mixing with wool for the manufacture of coarse woollens. Recent work at the Technological Laboratory has shewn that this rough feel is directly related to the wax content of the cotton, which, in its turn, is related to fibre diameter.

The special importance of Sind lies in the possibility of growing long stapled cottons, possessing a staple of 1¼", in the lands fed by the Sukkur Barrage. As will be shown later, our need for such cottons is very great, and unless it is satisfied from within the country, we have to import Egyptian and East African cottons. A short while ago 3 varieties, namely, Sind Sea Island, Boss III and Ashmouni, were evolved which gave promise of fulfilling this need, but though they were fairly satisfactory in respect of staple length and spinning performance, they failed on account of low yields, and their production after reaching a maximum of about 1,500 bales, dwindled to an insignificant amount. The Indian Central Cotton Committee has once again embarked upon a breeding scheme for the production in Sind of long stapled cottons, which should spin up to 60's counts and give a yield of at least 6 maunds of seed cotton per acre. Let us hope that this time these efforts will be crowned with success.

Both Sind and the Punjab have made remarkable progress in the past few years in the production of American types. In the Punjab nearly 55% and in Sind nearly 70% of the total area under cotton is at present under these cottons. Good as this progress undoubtedly is, there is room for further improvement, as the demand for staple cottons in India exceeds the supply. With large tracts in Central India, Central Provinces, Rajputana and Gujerat where short staple cottons are grown in abundant quantities, it is desirable that more of the canal irrigated areas in the Punjab and Sind should be diverted to the cultivation of staple cottons. The chief impediments in the way of their extension in certain areas are their comparatively low yields and ginning percentage, and it is necessary that future work should be concentrated on the improvement of these characters, while the length and fineness of the staple are not allowed to suffer a setback.

The second province contiguous to the Punjab, namely U.P., is remarkable in so far as no great progress has so far been made in the cultivation of staple or even improved varieties, the area under such cottons being only about 35,000 acres out of a total of nearly 5 *lakhs* of acres. This is all the more surprising as the number of cotton mills in the province has increased from 18 to 29 during the last 20 years. Many of these mills draw their supplies of staple cottons from the Punjab, while the Province itself imports large quantities of finer goods from outside. It is, therefore, desirable that the cultivation of staple cottons should be extended in the Province, so that they may satisfy bulk of its requirements. It is gratifying to note in this connection that the Indian Central Cotton Committee is financing a scheme for the development of improved varieties in the Province and that two varieties, namely Perso-American and C520, have given promising results.

In the past a good deal of work has been done in U.P. in discovering methods for eradicating the pink boll-worm, which sometimes exacted a heavy toll. It was found that heat treatment of the seeds before cultivation was quite effective, but this method could not be applied on a province-wide scale as an appreciable fraction of the seed-cotton never found its way to the ginneries, where it was proposed to instal the heaters. Thus, the practical results of this prolonged investigation have been insignificant. It is just as well to remember, in this connection, that if this method had been adopted all over the Province, it might have benefited some of the growers but it would have resulted in increasing the available supply of short-stapled cottons of which there is already a surplus in the country.

The Central Provinces, which I shall consider next, afford an example of what can be achieved by well-directed research on the one hand and well-advised legislation on the other in a short space of time. A few years ago practically the whole of the Province was under the short-stapled roseum cottons whose cultivation was in fact encouraged, at the expense of the longer Bani and Hinghanghat types, by the Japanese merchants who wanted cheap cotton for their mixings. The development of the Verum types, which have a staple of about $\frac{7}{8}''$ and are suitable for spinning up to 24/30's counts and their cultivation over an area of nearly 2,25,000 acres, have brought much higher monetary returns to the cultivators; while work is now in progress to evolve further selections from Verum, Bani, Buri, Lone Star, etc., which should be superior in respect of fibre properties and field characters.

The reputation of the C.P. cottons was marred for a long time by the malpractice of watering which was practised in the pressing factories. Recent work at the Technological Laboratory has shown that while cotton pressed in a uniform though fairly high humidity will retain its strength and spinning value for a long time, localized watering, as is bound to result from the above-mentioned malpractice, causes rapid discolouration and loss of strength. This is found to be primarily due to the action of cellulose-destroying fungi and bacteria. which multiply rapidly in the wet patches, even if the bale is subsequently stored in a dry atmosphere. Strenuous efforts by propaganda were made to lessen the evil; nevertheless, it persisted until the C.P. Government passed a legislation making it a criminal offence, when it disappeared as at the movement of a magician's wand. Such wise legislation often proves a valuable aid in the proper utilization of results of scientific research.

I shall now consider the province of Bombay which has the distinction of having the largest number of cotton mills among all the provinces of India. This province affords a fine example of a specific problem being solved by research, which has conferred considerable benefit upon the cultivators. The problem was the extreme susceptibility to wilt of Dharwar I which was superior in fibre properties and ginning percentage to the local Kumpta cotton grown in the Southern Marhatta country. It was solved by crossing Dharwar I with Dharwar II which, though inferior in staple, had shown high resistance to wilt. From the progeny, a strain was produced which combined the good characters of the two parents. It was named *Jayawant* (victorious), and is now being cultivated over 8½ *lakhs* of acres. The work on wilt resistance has been continued, and a special technique has been developed at Poona which weeds out all but the completely immune plants from an infected population. Another notable success in this province has been Jarila cotton, which possesses a fine staple of 13/16″ and is suitable for spinning up to 20/24's counts. It is rapidly replacing the Banilla cotton in Khandesh, and is now grown over an area of 70,000 acres. Another improved variety of the province, namely 1027 A.L.F., which is grown mainly south of Nerbudda river over an area of nearly 3½ *lakhs* of acres, has been the subject of a long and unfinished controversy between it and another cotton known as 1A Long Boll. While Surat 1027 A.L.F. possesses a whiter, silkier and somewhat longer fibre, 1A Long Boll is popular with some growers on account of its higher ginning percentage, and is also said to gain in value owing to its association with 1027 A.L.F. A happy solution of this difficulty would be the production of a variety which should combine the good characters of both the cottons, but unfortunately it has not been possible so far to evolve such a type, and in the meantime all efforts to have a large one variety tract are jeopardized every few years. Another area for which a suitable variety remains to be evolved is the Bijapur tract, where the rainfall is uncertain and where an attempt is being made to devise suitable dry farming methods for the cultivation of a cotton which would give the best monetary return to the growers.

From the industrial province of Bombay I shall pass on to the premier Indian State, Hyderabad, which was the home of one of the finest indigenous cottons, namely *Gaorani* or *Bani*. On account of its low ginning percentage, however, it steadily lost ground to the shorter but high ginning *neglectums*. The work for evolving an improved strain for this large and important tract was begun about 10 years ago, and as a result Gaorani 6 has been developed which is now grown over an area of nearly 2,42,000 acres. Further selections are being made from this cotton which should be even better in respect of staple length and spinning performance, while a selection from the local American varieties, known as *Parbhani-American* has been developed for Aurangabad district. In addition a scheme is in progress for improving the Kumpta Cotton grown in Raichur district.

This brings me to the province of Madras, the home of the soft *Cambodia* and the naturally coloured *Cocanadas*. One of the major problems in this province has been to find an effective check or remedy against the cotton stem weevil known as *pampheres*, which in a bad season may kill 25% of the plants in a field. After many years of work it has been found that neither physiological approach nor biological control provides sufficient protection against the ravages of this insect, and that the only hope lies in evolving a strain which would not allow the insect to complete its life-cycle inside the stem. Accordingly, work on these lines is now in progress at Coimbatore. It may be mentioned here that the improved variety of Cambodia, known as Co. 2, is now grown on an area of more than 2 lakhs of acres. Very recently a cross has been made between it and the Uganda Cotton, which possesses a fine staple over an inch long; and if this cross proves a success on the cultivator's fields, it will be a great help in satisfying India's requirements of long staple cottons.

The *cocanadas* cotton of this province is in demand on account of its natural colour which varies from creamy to brownish-red. Recently, a scheme has been sanctioned by the Indian Central Cotton Committee with the object of improving the yield and ginning percentage of this cotton while preserving at the same time its distinctive colour.

I have so far described briefly the salient features of the work on improvement in quality of cotton done in the major cotton growing provinces. Time does not permit me to consider in any detail the good work done in Baroda, Mysore, Indore, Gwalior, Rajpipla and other States. In Baroda the cultivation of 1027 A.L.F. and B.D. 8 has made good progress, while in Mysore an American variety named Mysore-American is grown on an area of about 10,000 acres. Rajpipla has, by wise legislation, reserved the whole of its cotton area of over 1½ *lakhs* of acres for the cultivation of 1027 A.L.F., while promising strains of Malvi are being tested at Indore for cultivation in Central India and the adjoining States.

I shall now consider two avenues of improvement which have been opened up very recently and which may lead to unexpected developments on an all-India basis. The first is the crossing of the Indian and the American cottons which had hitherto yielded sterile strains owing to the difference in the chromosome numbers of the two types of cottons. It now appears that it is possible to induce fertility by the application of colchicine to growing buds and tips of shoots, and work along these lines is now under way at Surat, while the cytological study of the hybrids is being carried out at Indore. The second avenue is the study of the effect on quality, earliness, yield, etc., of cotton of vernalization of its seed. Vernalization has already given surprising results in the case of wheat, mustard, tomatoes, etc., and some preliminary experiments carried out at Almora indicate the possibility that the quality and field behaviour of cotton may also be modified by it. These experiments are as yet in such an early stage that I am not in a position to say anything definite on the subject, but even if it is found, on further trials, that vernalization does not modify the properties of the fibre, it may radically affect the earliness of the crop and thereby provide a useful weapon for areas in which early frost or late rains affect adversely the yield or quality of the crop. It is, therefore, highly desirable that this new avenue of progress should be thoroughly explored at more than one centre of cotton research.

So far I have considered mainly the work on the improvement in quality of cotton completed or in progress in different parts of India. In addition, a great deal of work has been carried out, under the ægis of the Indian Central Cotton Committee and the Provincial and State Agricultural Departments on the agronomical side, including the study of such factors as manures and fertilizers, seed-rate, amount and frequency of irrigation, date of sowing, rotation with other crops, cultivation on ridges and flat, etc. Many of these factors, it has been found, do not affect appreciably the spinning performance and fibre-properties except fibre-maturity which is influenced by irrigation and type and quantity of manure, but they do influence, more or less, the stand in the field and the yield per acre and, therefore, the *net* return to the cultivator. In most cases the results of these investigations have been published in the form of memoirs and scientific papers, and are available to those who can read, understand and profit by them. The general standard of literacy in our country is extremely low, and there is an unfortunate tendency on the part of the educated men, even those belonging to the agricultural classes, to prefer a career of service in a town to a farmer's life in the open country. In short, those who can read do not till the land, and those who till the land cannot read. Consequently, the results of many of these investigations and researches remain a closed book to the cultivators. It is, therefore, essential, that the results of these investigations, so far as they are likely to improve the farmer's income, must be put across to them. A beginning has been made in this direction by organizing agricultural exhibitions, demonstrations and the so-called 'projects' in which a series of improvements are embodied, but considering the enormous size of the country, the extreme poverty and ignorance of the masses, the strong hold of tradition upon the population, these measures need to be intensified and adopted on a much larger scale. Furthermore, the Provincial Governments should come to an arrangement with the cultivators by which experimental plots of a fair size are cultivated by them (the cultivators) according to the instructions, or if necessary under the direct supervision, of the officers of the Agricultural Departments. These instructions should contain the quintessence of all those results of agronomical investigations which the Departments believe, after careful analysis, will benefit the growers, and in order to inspire confidence they should declare their willingness to make good any loss incurred by a cultivator who follows these instructions as against him who employs traditional methods. In this way the results of agricultural research will be taken right into the hearths and homes of the cultivators, but in order that this method may prove really useful, it is necessary that hundreds of such experimental plots should be scattered all over the country.

The question of better methods of cultivation is closely connected with the supply of pure seed of improved varieties in adequate quantities. In the preceding survey I have mentioned the names and the chief characteristics of a number of improved varieties of cotton which have been evolved for cultivation in different parts of India. It is, however, a significant fact that so far only 29 per cent of the total area under cotton has been brought under these improved varieties, while the remaining 71 per cent is still under types which cannot be regarded entirely satisfactory from every point of view. It is true that improved varieties, superior to the local cottons, are not available for every tract, but in several cases their extension is held up owing to the inadequacy of seed multiplication and distribution arrangements. These arrangements, if made for large areas, must cost a fair amount of money, but this money is well spent, as it ensures higher monetary return to the cultivator and a regular supply of better cottons to the industrialist. There has been a tendency in the past to debit the total or partial cost of seed distribution schemes to research. This does not appear to be quite correct, as the rôle of research is completed when an improved variety has been evolved and successive trials have shown it to be capable of giving better results than the local cotton. In my opinion the Provincial Governments should then come forward and take over the seed distribution work and extend it to cover the areas where the improved variety can be grown successfully. In this way they will help pure research by liberating the finances now spent upon these schemes from the central funds, and will do a good turn both to the cultivators and the industrialists.

This brings me to a consideration of some of the industrial aspects of cotton. It is well known that India is the second largest cotton growing country in the world, her annual crop of about 6 million bales being second only to the American crop. But if we take into account the number of spindles and looms, India occupies fifth place among the countries of the world, which at once brings out her industrial backwardness in respect of one of her principal cash crops. This backwardness manifests itself principally in two consequences which are not unrelated to one another. In the first place India imports a part of her home requirements in textiles from foreign countries, chiefly from Japan and Great Britain. Only 30 years ago these imports were very heavy, amounting to nearly 70% of her total requirements; but as India's textile industry developed, their volume diminished until now they amount to barely 12% of her consumption in normal times. This development of the Indian textile industry has enabled the mills to use increasingly larger quantities of Indian cottons, but even so the factory and extra-factory consumption of these cottons in India is only about 60% of the annual crop, leaving a balance of about 40% or nearly 2 million bales for which it is necessary to find export markets. The countries which provide these markets often demand concessions in return, which take the shape of our agreeing to buy a certain quantity of textile goods from them. It is clear, therefore, that the best way out of this invidious position, which makes India internally weak and externally dependent upon others, is to develop her textile industry to such a pitch that it should be able to use a very large proportion of her cotton crop. This can be done in three ways, namely, (*a*) by increasing the home consumption and satisfying it entirely from home-made goods, (*b*) by developing a foreign market, especially in the Eastern hemisphere, and (*c*) by altering the character of the Indian crop in such a manner that it fits in more closely than at present with our industrial requirements. I shall now consider these three aspects briefly.

India has the largest home market in the world with the possible exception of China. But though this market is quantitatively large, the consumption per capita is small, being only 15 yards per annum. I give below a table showing the consumption of cotton textiles per head per annum in various countries, from which it will be seen that India occupies a very low position, in this respect, among the civilized countries of the world, and that the consumption per head even in Cuba, Gold Coast, West Indies, Malaya, etc., is greater than in India.

TABLE I.

Consumption of cotton piecegoods—yards per head (1936).

Country.	Yards per head.	Country.	Yards per head.
Sweden ..	38	Malaya	22
Argentina ..	38	West Indies ..	22
Denmark ..	34	Gold Coast ..	20
Norway	33	Cuba	20
New Zealand ..	30	Egypt	18
Canada	28	Columbia ..	18
Australia	27	Venezuela ..	17
South Africa ..	23	Dutch East Indies ..	11·5
S. Rhodesia ..	21	Ceylon	11·5
Ireland	17	Nigeria	8
Greece	10	French West Africa ..	8
India and Burma ..	15		

It is, therefore, necessary that the consumption per head of cotton textiles should be increased in all possible ways, so that the Indian mills may be able to consume larger quantities of Indian cottons. It might be possible to achieve this end by propaganda and a gradual increase in the standard of living; but these are slow measures, while the problem is urgent and demands a quick solution, such as reduction in the price of textile goods which would enable the masses to buy more cloth. For this purpose it would be necessary to keep the costs of production as low as possible compatible with satisfactory quality of goods and the capacity of mills to make reasonable profits. A fierce controversy has raged on this point, both capital and labour accusing one another of imposing avoidable burdens on the shoulders of the consuming classes. Such controversy is unprofitable and benefits nobody in the long run, as the world economic forces are far stronger than the interests of any special class. The whole question should be viewed dispassionately in the wider interests of the country as a whole, and wherever it is found that the overhead charges, agency commission, cost of administration, middleman's profit, etc., are excessive, they should be curtailed, while if it is found that the wages per unit of production are high as compared with the competing countries, the efficiency of labour must be raised by a suitable amount. Furthermore, the Indian mills operate under a handicap of import duties on textile machinery, stores, dyes, auxiliaries, etc., and though they are protected against foreign competition by import duties on cloth, it would certainly help them to reduce their costs of production, if the machinery, stores, etc., could be manufactured in the country. The raw materials, iron, timber, mineral, etc., required in their manufacture are available for the most part, and it is necessary that they should be diverted to the manufacture of goods which would help the existing industries rather than that all these materials should go in the making of goods which are only end products. Finally, full advantage should be taken of technical advance and schemes of rationalization to reduce costs of production, wherever possible.

I shall now say a few words regarding the development of India's foreign markets in piecegoods as an aid to greater consumption of her cottons. I have mentioned above that in the middle ages India exported large and valuable quantities of textile goods to foreign lands. As late as 1815 the value of the piecegoods exported to England alone amounted to £1,300,000, which in those days was quite a large sum. After the death knell of the hand spinning and the hand weaving industry had been sounded and India had established a textile industry on the modern mechanical lines, she developed a fairly good export trade in cotton yarn and piecegoods, principally with China. In 1909 she exported 227 million pounds of the former and 94 million yards of the latter. At that time Japan entered the market as a powerful competitor, and with her better organization, closer collaboration between the banks and the textile and shipping industries and assistance from the State practically drove India out of this market. If the Indian mills are to use larger quantities of Indian cottons, it is necessary that they should be able to export a reasonable proportion of their piecegoods to foreign countries, especially in the Indian littoral. It is interesting to recall in this connection that the Government of India trade mission which visited Egypt, Iran, Iraq, East Africa, etc., in 1927-28 came to the conclusion that the Indian mills should be able to secure additional markets to the extent of 100 million yards for their piecegoods in these countries. Actually, the export market, instead of expanding, had shrunk until recently when Japan's entanglement in China and the bloody storm now raging in Europe once again opened these markets for us. While every one here would deplore the terrible loss of life and property which is now going on in Europe and China, we should, at the same time, make every effort to develop our export trade and find outlets for the piecegoods that can be manufactured from our cottons. In this connection it has been suggested that an export organization, representative of all the intersts concerned, should be set up by the collaboration of the Government, the trade and the industry. This is an excellent suggestion and should be put into effect as early as possible. Furthermore, I should like to commend two suggestions which may either be incorporated in the above-mentioned suggestion or considered independently. In the first place observers should be sent to the various potential markets with instructions to study closely and in great detail the requirements of each market in quality and type of piece-goods and yarn and report them to the authorities at home, so that the goods, manufactured according to these specifications may easily find favour with the consuming classes. Secondly, some sort of organization, in the form of a Testing House or Board of Inspection, should be set up to ensure that the goods exported to these countries are of uniformly good quality, so that the markets once captured are not only retained but strengthened for the future.

I shall now say a few words regarding the third point, namely the attainment of a better equilibrium than that which exists at present between India's cotton crop and her industrial requirements. It has been stated above that India's total output of cotton is nearly 6 million bales. But this crop, large as it is, is lopsided in so far as it contains a surplus of short and medium stapled cottons and a deficiency of comparatively longer types. Spurred by the demands of the market and competition from other countries, the Indian cotton mills have exhibited a strong tendency in the past few years to spin increasingly large quantities of the finer counts for which long staple cottons are required. This will be seen from the following table which gives the distribution of counts spun in Indian mills since 1930.

If we divide this period into two halves, it will be noticed that whereas the production of counts 1–10's in the second quinquennium is practically the same as in the first, that of counts 11–20's shows an increase of 15%, that of counts 21–30's an increase of 9% that of counts 31–40's an increase of 90%, while the production of yarns above 40's registers an increase of 116%. During approximately the same period the production of cottons possessing a staple length of $\frac{7}{8}''$ and above increased from 26% of the total crop in the quinquennium 1928–33, to 32% in the quinquennium 1933–38 registering an increase of only 6%. These figures bring out, in a striking manner, the wide gap which exists between India's requirements and her production of long stapled types, which has to be filled up by importing, in normal times, about half a million bales of foreign cottons. In order to remove, or at least to reduce this disparity, it is necessary that on the one hand more and more long stapled types should be grown wherever their cultivation can be made an economic proposition, and on the other hand every effort should be made to increase the consumption of our surplus of short and medium stapled cottons. The former object might be achieved by making provision for the supply of seed of improved varieties in larger quantities and for areas

TABLE II.

Quantity of yarn spun in India

(in thousands of pounds).

	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939
$1^s - 10^s$ ..	112,432	117,197	118,123	107,432	108,673	110,830	111,905	108,634	134,877	129,539
$11^s - 20^s$ ..	402,833	428,823	482,312	451,629	452,762	475,859	489,582	481,301	543,322	552,414
$21^s - 30^s$ ..	265,233	284,328	305,298	260,117	273,966	286,147	274,935	291,024	335,956	324,518
$31^s - 40^s$ ..	56,657	68,222	77,566	73,132	91,201	111,166	113,813	148,452	167,717	157,201
Above 40^s ..	23,612	33,161	35,994	36,475	42,307	56,557	57,066	81,286	91,613	84,647
Wastes ..	6,258	5,174	5,630	5,646	5,962	5,653	7,826	10,133	14,050	15,690
Grand Total ..	867,025	936,905	1,024,923	934,431	974,871	1,046,212	1,055,127	1,120,830	1,287,535	1,264,009

in which the soil and climatic conditions are favourable. In this connection it is well to remember that sometimes short staple cottons may fetch abnormally high prices owing to their demands for special purposes, such as the manufacture of ammunition. However, these transient considerations should not be allowed to influence unduly the broad lines of policy which should be guided by a comprehensive and long range view of industrial requirements.

The consumption of short and medium stapled cottons in the Indian mills might be stimulated by imposing a protective duty upon imports of foreign cottons provided the duty on piecegoods and yarn imported into India is also increased by an equivalent amount. The consumption of short and medium stapled types might also be increased by finding new and non-textile uses for them. It is said that in the U.S.A. nearly 40% of the total cotton crop is used in industries other than those dealing with the manufacture of cloths. Now, it is true that industrially we are far behind U.S.A., but we are at least on the threshold of industrialization, and the future holds good promise for us. Therefore, if at this stage, we bear in mind the problem of our surplus cottons and find new outlets for them, we might be able to consume quite a large amount in these new industries. I give below a list of some of the uses to which cotton may be put in this manner. This list is by no means exhaustive, and it would be possible to add to it by further examination and reflection, but it will be noticed that even in its present form it contains quite a large number of items which are well worth a trial.

List.

1. Rayon manufacture.
2. Road making.
3. Bagging for cotton bales.
4. Sugar bagging.
5. Pneumatic tyres.
6. Car manufacture.
7. Aviation and Aeroplanes.
8. Sheep coats.
9. Wrapping meat for export.
10. Absorbent cotton.
11. For machinery bearings.
12. Imitation leather trunks.
13. Canvas shoes.
14. Substitute for wall paper.
15. Canvas boats and canoes.
16. Hosiery goods.
17. Cheap carpets.
18. Type-writer ribbons.
19. Fishing nets.
20. Pipes for conducting acids and corrosive liquids.
21. Veneer wall coverings.
22. Linoleum and oilcloth.
23. Cotton belts and belting.
24. Filter cloth for milk, oil and sugar factories.
25. Pyroxylin coated fabrics.
26. Golf club shafts.
27. Covering for tobacco plants.
28. Covering for dried fruits in the curing process.
29. Lining for irrigation canals and terrace outlet ditches.
30. Valves for oil valve drilling equipment.
31. Housing material for electric vibrators.
32. Rubber proofed garments.
33. Cotton bags for cement.

The quantity of cotton required would naturally differ for the different items included in this list, being fairly large for some and quite small for the others. Thus, it is estimated that each motor car takes up about 70 lbs. of cotton for its upholstery, cushions, tyres, etc., while the quantity required in the manufacture of typewriter ribbons is quite small. But it must be remembered that in this matter every little consumption helps, and that the cumulative effect of all the items can be quite large. It is gratifying to note in this connection that experiments have already been started at the Technological Laboratory to explore the possibility of using cotton fabrics in road construction and for the preparation of bale coverings and sugar bags. While these experiments are in progress, attempts will also be made to explore other uses of cotton, which may tend to increase its total consumption in India or help in building up new industrial enterprises. It must, however, be remembered, in this connection, that in several cases the technical aspect of the problem is fairly clear, but economic considerations or lack of adequate industrial utilization stand in the way of more cotton being diverted to newer channels. Thus, very recently, when the price of jute went up, a number of Indian cotton mills, both in the North and in the South, started manufacturing cotton hessian cloth, which was used for covering cotton bales. It was reported to possess several points in its favour, but before the whole problem could be investigated, the price of jute fell, and the cotton hessian cloth was driven out of the market. In this connection we must also remember that our problem is much more complicated than that of U.S.A. or Egypt, and that if we take an all-India view, as we must, we should pay due attention to the relative claims of all the Indian fibres in preparing our programme of action.

Gentlemen, I have now completed my survey of Indian cottons, and will now turn to another very important Indian fibre, namely jute.

JUTE

Unlike cotton, which is grown over the length and breadth of India, the cultivation of jute is restricted to the eastern provinces of Bengal, Bihar, Orissa and Assam. This is not the only point of difference; there are others which are equally interesting. Thus, whereas India provides only about 20 per cent of the world supply of cotton, she enjoys a virtual monopoly of jute, since the efforts to grow this fibre in other countries have not so far proved very successful with the exception of Formosa, where Japan has succeeded in raising a crop of about 30,000 tons or 165,000 bales. Again, while India uses up for her own needs nearly 60 per cent of her cotton crop, her requirement of jute goods is covered by 14 per cent of the total crop of about 8–10 million bales, the remaining 86 per cent being exported to foreign countries in the form of raw fibre or jute goods. Thus, jute provides a set of distinctive problems, and I shall now consider some of them.

Though jute is one of the most important of India's fibres, apparently no systematic work was undertaken on it until 1906 when the Government of Bengal inaugurated a Fibre Section in the Department of Agriculture. Since then some valuable work has been done, especially on the agricultural side, and I understand that the Government of Bengal intend to issue a detailed review of this work. Since 1937 the work on jute has been brought under the direction of the Indian Central Jute Committee, which is a representative body set up by the Central Government and charged with the task of (1) undertaking agricultural, technological and economic research, (2) making arrangements for the production, testing and distribution of improved seed, and (3) devising methods for better crop forecasting.

I shall first consider the work done, or in progress, on the agricultural side. One of the most important problems in this field is to increase the yield of fibre per acre so that the cultivator may get a higher monetary return for his labour or alternatively some of the 3 million acres now under jute may be released without reducing the present size of the crop. The yield of fibre per acre depends upon several factors, chief among them being (*a*) height of the plant, (*b*) fibre content of the plant, (*c*) resistance to diseases and pests, and (*d*) density of plant population. It is satisfactory to note that investigations have been started at the Agricultural Research Laboratories of the Indian Central Jute Committee at Dacca with a view to studying the influence of these factors and their dependence upon heredity, environment and cultural treatment. Several improved varieties, such as D. 154, D. 386, Fanduk and Kakya Bombai are being grown on agricultural farms in different parts of Bengal and Assam, and the produce is examined in great detail. A new method has been developed for estimating the fibre content of a plant by a microscopic examination of a slice of its stem. This method obviates a difficulty which had been encountered so far, namely, when the fibre content of a plant was estimated, measurements could not be continued on the rate of increase of its height. Furthermore, a thorough study is being made of the development of fibres in the plant and the arrangement of cells in each fibre in order to understand the fundamental relationships between quality, inheritance and environment. It has been observed that the development of the fibre comes to an end with the close of the growth phase which leads to the conclusion that the harvesting of jute may well synchronize with this phenomenon. It has further been noticed that the fibres on the outer parts of the stem or near the lower portion of the plant have longer and wider mesh, which corresponds to coarse quality, while those near the top of the plant or lying inside the stem have a finer texture.

The question of yield of fibre per acre is intimately connected with that of the resistance offered by the plant to the incidence of disease and the attack by pests. In this respect jute is much more fortunate than cotton, as it is subject to only two serious diseases, namely, (*a*) Stem-rot, and (*b*) Chlorosis; while only three insects, namely jute-semilooper, the hairy caterpillar and the indigo caterpillar cause appreciable depredation. Work is now in progress with a view to evolving varieties which offer better resistance to the above-mentioned diseases, or to discover cultural treatments which, by giving greater health and vigour to the plant, enable it to fight the disease more successfully. It has been found that the variety known as Tosha is more resistant to stem-rot than *Deshi*, while the application of nitrogenous fertilizers in combination with either potash or phosphate fertilizers reduces the incidence of the disease. It is interesting to note, in this connection, that as against stem-rot, the application of nitrogenous fertilizers *increased* the incidence of the second disease mentioned above, namely, chlorosis, which seems to be confined to *Deshi* plants. It is thus clear that a satisfactory cultural treatment remains to be worked out, which should help the plant in fighting both diseases, or at least should reduce the incidence of one disease without increasing that of the other. Furthermore, much more work is necessary in order to evolve varieties which should be naturally more resistant to attack from either of these two diseases, as cultural treatments are not always within the economic reach of the poor cultivators.

This brings me to the question of improvement in quality of jute, which can also be studied simultaneously with the development of disease-resisting varieties. Nearly 80 per cent of the jute produced in India is consumed in the manufacture of very coarse fabrics, such as gunny bags, sand bags, sacking cloth, etc., which are used for the transport and storage of other materials; and it is reasonable to suppose that it will continue to be used for such purpose until a cheaper and equally serviceable substitute has been found. But the remaining 20 per cent is used for the manufacture of finer goods, such as carpets, canvas, furnishing materials for curtains and upholstery, union fabrics, etc.; and attempts are being made to extend these uses of jute. It is for this class of goods that better qualities of jute, possessing a longer, cleaner and more pliable fibre are required, and work has already been started at Dacca and other farms with a view to evolving such varieties. A very large number of selections have been made, and their field behaviour, yield per acre, resistance to disease and pests, etc., are under observation. Furthermore, technological tests are being carried out at Calcutta on the more promising of these varieties, so that the final selection may be made on the basis of field characters as well as spinning tests. In this connection it is necessary to disentangle the effect of variety from environment, as the same variety may give widely different results when grown under different conditions of soil and climate. Furthermore, as in the manufacture of finer goods, such as furnishing materials, it may be necessary to give scouring and bleaching treatments, which partially remove the cementing substances between the ultimate fibres, it is suggested that along with spinning tests on these improved varieties, fundamental investigations should also be undertaken on the length, diameter, etc., of the ultimate fibres of these varieties, as the strength and durability of the fabrics would depend, to some extent, upon these characters.

The question of improving the quality of fibre is also related to the process of steeping, stripping and washing, which are performed by the cultivators before jute is ready for baling. Sometimes these processes are carried out in a manner which has deleterious effects on the quality of the fibres; for example, sods of earth are used for weighing down the stack, which causes discolouration, or the fibre is weakened by over-retting. Furthermore, the presence of mineral salts in the water, which may vary in type and amount from place to place, may have some effect upon the strength of the fibre. It is necessary that all these points should be investigated, so that the botanical efforts at improvement in quality are not vitiated by staining or weakening of the fibres during the retting process.

I will now say a few words on the industrial and technological aspects of work on jute. The Indian jute mills situated along the bank of Ganges take up about 65% of the jute produced in India, while the remainder 35% is exported to different countries. These mills manufacture mostly heavy goods such as hessian cloth, sacking cloth, bags, etc., of which nearly a million tons are also exported out of the country. The finer varieties of goods such as furnishing materials, carpet-backing, rugs, mats, imitation tapestry, webbing, etc., are mostly prepared in foreign countries out of the jute imported from India, and some of them are exported back to this country and sold at a good profit. Even in the case of heavy goods made in India the percentage ratio of the price of manufactured goods to that of raw jute has varied from 132 to 166; while in the case of the finer qualities this ratio must be much higher. It shows that while we must make every effort to conserve our foreign markets in hessian, bags, etc.; we must also strike out in new directions and start manufacturing and exporting the finer qualities so that greater income is secured to the country. It is gratifying to note in this connection that Indian Central Jute Committee has already accepted this view in principle, and has sanctioned expenditure for an extension of their Technological Laboratories at Calcutta and installation of machinery for spinning fine counts of yarn from jute. This is a step in the right direction; but in order to be fully effective, it should be supplemented by the installation of a few looms and machinery for carrying out investigations on the scouring, softening, bleaching and dyeing of jute goods, so that complete investigations may be undertaken on the manufacture *in India* of finer qualities of jute fabrics. If it is done, it will help in laying the foundation of new jute manufacturing industries in this country.

In the case of heavy jute goods the problem of rot-proofing has recently come into great prominence. Millions of sand bags, made out of hessian cloth, are being used for protection against explosive and incendiary bombs; and it has been noticed that in some cases these bags rot away in a few months. This problem has been tackled by several workers, and it has been found that rotting might be due either to the action of bacteria and fungi in a damp climate or to the action of sunlight in a relatively dry weather. So far as rotting is brought about by the action of bacteria and fungi, jute is not more susceptible than other fibres such as flax, cotton, etc.; but it loses strength much more rapidly than the other fibres under the action of sunlight. It has been found that a certain amount of protection against micro-organismal infection is afforded by treating the material with metallic soaps or with salts of naphthenic acid; while the best protection against the action of sunlight is given by a cutch-chrome treatment. It would indeed be very desirable if other, more effective and cheaper, treatments were discovered. which would prolong the life of jute goods. Research is also needed in order to render these goods, when required, fire-proof and damp-proof. The necessity for these researches is indicated by the fact that efforts are now being made to find new uses for jute, including wall covering and reinforcement for roofing materials, where the acquisition of these properties would be very desirable.

In view of the fact that most countries do not grow any jute, while they have to use hessian cloth for the transport and storage of their goods such as coffee, sugar, cotton, grains, flour, etc., efforts are being made in several places to grow fibres which could be used as substitutes for jute. These efforts have not proved very successful so far, as fibres like *Roselli* in East Indies, *Urena Lobata* in Belgian Congo, *hibiscus* fibre in Brazil, etc., have neither proved equally serviceable nor suitable for certain commodities like cocoa, ground tin, ground manganese, etc. But it is very necessary to watch these efforts with deep interest, as agricultural development in the production of any of these fibres, or technological development in improving their properties, might easily bring about a crisis in the lives of millions of people engaged in the cultivation, marketing and manufacture of jute. Furthermore, it is desirable that a satisfactory equilibrium should be maintained in the price of jute, so that while the farmer gets a good return for his labours, the price is not so high as to tempt the rival or substitute materials to capture a part of the jute market. It may be mentioned, as an illustration, that in 1925 when the price of jute soared up to £60 per ton, the cement companies started using paper bags, and it is estimated that the jute trade lost permanently to the extent of 15 million bags per annum. In recent years both the area under jute cultivation as well as the productive capacity of the jute mills have shown distinct signs of exceeding the world demand, and several schemes have been put forward for restricting either one or the other. It is necessary that these schemes should be examined dispassionately and scientifically so as to evolve a line of policy which should safeguard the interests o both agriculture and industry.

COIR

From the water-submerged fields of Bengal I must now turn to the sunny South where the tall, slim and swaying palms lend so much beauty and charm to the landscape. These trees not only provide copra which is exported in large quantities, but also the coir fibre which is used extensively in the manufacture of ropes, cords, mats, carpets, etc. The coir fibre industry resembles the jute industry inasmuch as it is concentrated in certain well defined tracts of India; but unlike both cotton and jute, it has remained very largely a cottage or village industry up to the present day. It would, therefore, be instructive and interesting to consider some of the aspects of an industry, which, at least in India, has not yet enlisted the aid of large scale power-driven machinery in any of its processes.

It is rather difficult to give an exact figure for the area under cultivation of the cocoanut palm in India. One estimate puts it at $1\frac{1}{2}$ million acres, which represents about 20 per cent of the total area under this palm in the world, made up chiefly by large areas in the Dutch East Indies, Philippine Islands and Ceylon. The average yield in India has been estimated to be about 5 cwt. of fibre from an acre of plantation, giving a total yield of about 300,000 tons of fibre. Some of it is exported to foreign countries in the raw state, but a good deal of raw fibre is also imported from Ceylon. The indigenous as well as the imported fibre is converted into a number of useful articles such as ropes, cords, bristles, mats, brushes, mops, etc., and large quantities of these manufactured goods, amounting to some 650,000 cwt., are exported each year from the country. It would certainly be interesting to make an enquiry as to why, in the face of such abundant supplies in India itself, raw fibre is imported from Ceylon; whether it is due to economic reasons such as the low price of the Ceylonese material or it is due to some special type which they are able to grow in the Emerald Isle, and whether these factors cannot be countered so as to make India self-sufficient in respect of this fibre.

One of the most important problems facing this industry is that of retting which includes soaking, steeping, beating, drying, etc., in order to obtain the fibre from the husk. The details of the method followed by the cultivators and artisans differ from one area to another. In some places sea water, brought by the tidal action in long channels with narrow openings, is used, while in others fresh water is employed in tanks or ponds and changed by manual labour. The method of keeping the nuts submerged in water, the depth of the channels, tanks or ponds, the nature of salts present in the water, the frequency of changing the water, etc., also differ from place to place. But in all this variety one factor remains more or less constant; it is the duration of steeping, which extends from about 8 to 10 months. It is indeed fortunate that the coir fibre offers very good resistance to the destructive action of water and bacteria, otherwise it may be imagined that such prolonged soaking in water, which is not always clean, would reduce it to tiny and useless shreds. Even so, it is not certain that the strength, elasticity and colour of the fibre do not always deteriorate as a result of such long contact with water. It is in the direction of reducing the time of retting that a thorough investigation is urgently needed, which, besides improving the quality of the fibre, should also have the economically valuable effect of partially liberating labour from their long vigil over the channels, tanks and ponds in which cocoanuts are placed for retting. In order to appreciate this point, it is necessary to understand the mechanism of the process of retting. Some work has been done on this problem and it has been found that the separation of fibres is brought about by the action of certain micro-organisms which are present in the husk itself. These bacteria disintegrate the gummy substances, which are distributed more or less uniformly in the pithy material between the fibres and which help to bind them together. The water in which the nuts are soaked for several months provides the necessary conditions for the growth of these bacteria, while the change of water at regular intervals helps to remove the products of their action which otherwise might poison them. These bacteria operate best at a certain range of temperature, and if the temperature is allowed to fall below the lower limit, their activity is greatly reduced. They also remove the superfluous oxygen from the water, which, if allowed to accumulate, causes reddening of the fibre due to oxidation of tannin matter. Thus, if the bacteria are removed by too frequent changes of water, or their activity is reduced by low temperatures prevailing for long periods of time, the reddening of the fibres will take place, which may detract from their market value. Similarly, if the bacteria do not, for any reason, finish their job of completely disintegrating the gummy substances, the pithy material will remain adhering to the fibres, which will not fetch a good price. These are not hypothetical suppositions, but conclusions drawn from actual observations, as is shown by the fact that in an analysis of a large number of coir yarns carried out at the Technological Laboratory, the percentage of pith in soaked samples was found to vary from 0·1% to about 4%, while for the unsoaked samples it was much higher, rising to about 45% in some cases. Similarly, the colour of the yarns varied from pale cream to crimson, and the moisture content and the tensile strength also showed enormous variation. The variations are undoubtedly, to a large extent, due to the crude, unscientific and time-absorbing methods of retting, which are followed by the cultivators and manufacturers. It is, therefore, very necessary that the whole problem should be studied from the practical point of view so that greater uniformity, at a high level of quality, may be achieved in the raw product. But more particularly it is necessary that this investigation should be aimed towards reducing the total time required for completing the separation of fibres without impairing their quality. This may be achieved either by artificially raising the temperature of the water so as to increase the activity of the bacteria during day and night, or by employing a bacterio-chemical treatment in which the process begun by the bacteria naturally existing in the husk is completed by chemicals which may remove the gummy substances. But whichever method is tried it should be quick and cheap, as expensive methods which have been worked out, are outside the means of the poor farmers. Thus, a Dutch scientist has evolved a process in which the fibres are separated by digesting the crushed husks in a large kier in suitable liquors, but the plant before the war cost over Rs.5 lakhs. Such expensive methods, however efficient, are not within the means of the Indian farmers or merchants, and hence the necessity of keeping in view the cost of the treatment.

Another important question which is closely related to the retting treatment, is the determination of the degree of ripeness of the nut at which the husking and retting treatments should be started. The general practice is to remove the nuts from the trees while they are still somewhat unripe and start the above-mentioned operations soon afterwards without storing the nuts for any length of time. The labourers, who climb the trees to remove the nuts, are, it is reported, steadily decreasing in numbers owing to the risky nature of the job and the attraction of more lucrative and safer employments. Consequently, if retting treatments can be devised which are capable of giving the same quality of fibre from ripe nuts which automatically fall on the ground, this problem would be solved in a satisfactory way, and a great deal of labour would be released for other work on the fields. Some work has been attempted in this direction, but it is necessary that it should be tackled in a thorough manner.

The problems relating to coir fibre are not confined to the agricultural side, but extend to the possibility of manufacturing many new products from this material in addition to those which are already being made. It has been mentioned above that this fibre possesses excellent resistance to water and bacterial attack. It is, however, very brittle and possesses a harsh feel, which ordinarily makes it unsuitable for the manufacture of any but the coarsest materials. This is probably due to the extremely small size of its ultimate fibres, which measure 0·4–1 mm. in length and 12–24 microns in diameter, and are probably the shortest fibres in the vegetable kingdom. If, however, the fibre can be softened and rendered more elastic by a chemical treatment without impairing its good resistance to water and bacterial attack, it would be suitable for making numerous articles, either singly or in combination with other fibres such as jute, hemp, agave, etc., especially those which are required to stand against the action of water or damp weather. Its use for such articles and also for carpets and rugs would be extended if the bleaching and dyeing of the fibre could also be studied exhaustively, so that it may be possible to produce attractive effects in the articles manufactured from it. It is in my opinion the duty of the Governments of Madras, Mysore, Travancore, Cochin, etc., to promote co-ordinated scientific investigations on these lines in the laboratories of their Universities and technical institutions.

Conclusions

Gentlemen, I had originally intended to devote a part of my address to the consideration of other Indian fibres, especially wool, silk and sunn-hemp, and the possible effects of the development of synthetic fibres on our natural fibres, but I have already exceeded the limit normally allowed to the President of a Section for his address, and I must therefore postpone consideration of these important fibres to some other time and occasion. I must, however, say a few words regarding the competition offered by the synthetic fibres, as I believe that their development holds vast potentialities of affecting the lives of millions of people engaged in the cultivation, marketing and manufacturing of natural fibres in India. This development has been so remarkable that it may well be regarded as one of great romances of modern applied science. In the short span of 30 years, the production of rayon or artificial silk, which is only one of the synthetic fibres, has increased to about 1 million tons or nearly 10 per cent of the total world production of fibres of all kinds. There is every reason to believe that this development will continue at an undiminished rate, especially in countries like Japan, Germany and Italy which are deficient in some of the natural fibres and which before the war produced nearly 75 per cent of the world's output of rayon. In addition to rayon, which comprises both the viscose and acetate art-silk, numerous other synthetic fibres such as lanital, lactofil, fibramina, vistra, cisalfa, vinyarn, nylon, etc., have been placed in the market, and are being used singly or in union with other fibres for the manufacture of textile goods. The extent to which we, who grow natural fibres in such abundance, have become addicted to their use may be gauged by the fact that before the war we were importing rayon goods worth Rs.2 crores per annum. We may, therefore, enquire into the causes of this compelling popularity, which seems to carry everything before it. These are briefly threefold. In the first place there is the strong desire on the part of certain highly industrialized countries to utilize fully their natural resources, so that while they conserve their exchange and profit by their exports during peace-time, they also attain a measure of economic self-sufficiency in the matter of their vital supplies in the event of war or general blockade. This consideration is especially important to countries who unfortunately believe in resorting to war as a means of solving their political or economic problems. Secondly, the physical and chemical properties of these synthetic fibres can be modified quickly, over a wide range, by suitable alteration in the chemical treatment or adjustment in a mechanical process. This feature endows them with much greater elasticity and variety of use than that possessed by the natural fibres. Thus, while it may require painstaking research lasting over several years to increase the staple length of a variety of cotton by $\frac{1}{8}$th of an inch, the mean length of the staple fibre, which competes with cotton, can be varied at will from $\frac{3}{4}''$ to $3''$, or even longer, by a quick adjustment of the cutting knife. Similarly, the fineness, lustre, colour, strength, etc., of these fibres can be varied over a wide range, which gives them great advantage over the natural fibres where any change, however small, is bound to be slow. Thirdly, the space required for putting up a factory, which will produce vast quantities of synthetic fibre, is quite small compared to the vast areas necessary for the cultivation of natural fibres, and this consideration is especially important to over-populated and congested countries. Thus, a factory has been recently put up on $3\frac{1}{2}$ acres of land which is capable of turning out 16 tons of finished rayon yarn per day. Assuming 300 working days in the year and taking the average yield of lint in India as about 100 lbs. per acre, it would require the production of over 150,000 acres of land to manufacture the same quantity of yarn in a cotton mill. Hitherto, some limitation was imposed in respect of the area required for the production of these fibres, because ultimately they were derived from natural products such as timber, reeds, milk, etc., but with the development of nylon-like fibres, which are made from coal, water and nitrogen (from the air) even these limitations have disappeared, and it would now be possible to turn out vast quantities of synthetic textile fibres from a factory occupying a few acres of land, which may stop cultivation of natural fibres over several lakhs of acres, plunging the poor farmers into the abyss of poverty and distress. Thus, the potential danger from these synthetic fibres to our natural fibres is very real, and it may become extremely grave if proper and effective steps are not taken in time. Several remedies have been suggested for meeting the new situation created by the rapid development of these fibres and their encroachment upon fields which were hitherto regarded as the legitimate preserves of the natural fibres. Some of these remedies tend to ignore the march of time by denying the necessity or postponing the inauguration of any exploratory work in India, while others seek to take shelter behind tariff walls and import barriers. In my humble opinion the former remedies are short-sighted and unwise, while the latter course can at best be regarded as a temporary palliative. I think we should frankly recognize that the synthetic fibre has come to stay, like the steam engine, the electric motor, the aeroplane and numerous other scientific inventions, and that, like them, though it may at first cause a certain amount of dislocation in the old order of things, it must find its proper place in our national economy and industrial development. Attempts at suppression or postponement are likely to prove as harmful in the long run as uncontrolled importation or unplanned production. It is necessary that we should survey the whole situation in an objective manner, take stock of our production of natural fibres of all kinds, their present and future demand in the home and foreign markets, their possible new uses and our requirements in synthetic fibres for the manufacture of union or special fabrics and other goods. This data should be considered by a body of men representing all interests, who should recommend suitable measures for harmonizing the undoubtedly powerful claims of our natural fibres with the controlled development of synthetic fibres in the country.

I will now bring this address to a close with a story from old Iran. It is said that when the great Persian poet and moralist, Sa'adi, visited Ispahan for the first time, he had but a few coppers in his pocket, and the problem which confronted him was how to feed himself, his mule and his parrot on this meagre amount. Remembering that the people of Ispahan were famous for their native intelligence, he decided to consult the first person he met in the street. This happened to be a small boy, who, on being informed of the situation, looked at Sa'adi with wonder in his eyes, and said 'It is strange that a grown-up person like you should not be able to solve such a simple problem. Buy a large and succulent melon with your few coppers, eat the marrow yourself, give the husk to your mule and feed the parrot on its seeds, and your problem is solved'. Thereupon, the chronicler goes on to say, Sa'adi composed his famous verse, '*Gahe bashad ke kodak-i-nadan* . . . . .', thanked the boy and acted on his advice to the complete satisfaction of himself, mule and parrot. This story has a moral for us. We are a poor people with many mouths to feed and with very little in our pockets at present. But a bountiful Nature has given us raw materials of every kind, minerals, timbers, fibres, cereals, nuts, seeds, etc., and if we properly husband, utilize and develop our resources, we can satisfy the needs of our millions of inhabitants at a decent standard of living, and make our country rich and strong and respected by the other nations. All that is necessary is the Will and the Ability to do it on our part. Let us then resolve to devote ourselves to this task, remembering the value of scientific research, which is perennially young and progressive, and the youth of our country who alone can bring fresh enthusiasm and new outlook into the solution of our great problems.

Gentlemen, I thank you sincerely for the courtesy and patience with which you have heard this address.

SECTION OF PHYSIOLOGY

President:—B. T. KRISHNAN, B.A., M.B.B.S., M.Sc.

Presidential Address

(Delivered on Jan. 4. 1942)

THE NEED FOR THE EXPANSION OF PHYSIOLOGICAL AND PHARMACOLOGICAL RESEARCH IN INDIA

'The only duty of Science is exact statement; its only service, truth.'—
H. G. Wells.

LADIES AND GENTLEMEN,

It is my first duty to offer my most sincere thanks to my colleagues for the great honour they have done me in asking me to preside over the deliberations of the 7th session of the Physiology Section of the Indian Science Congress. I am deeply conscious of the great responsibility I have accepted and also the limitations of my own capacity to discharge this responsibility, but I hope I can count on your kind co-operation and indulgence to make this session a thorough success.

I would like to dwell this year on the need for the expansion of physiological and pharmacological research for the advancement of Medicine in India, as this subject is of paramount importance to the country at the present moment.

At this juncture, I should not fail to refer, to start with, to the great disastrous World War II that is raging at present. We all fervently pray for and anxiously look forward to the success of Britain in this greatest war known in History. The salvation of India and our fortunes are entirely bound up with British victory. With British victory and success for Democracy, a new World order is inevitable and it is certain that India, affected by that order, will come to its own politically, industrially, and economically. It is but right that we, as scientists, should strive and see that India, in this new order, comes to its own scientifically as well.

Notable and admirable work has been done and is being done in this country in the domains of physics, chemistry, and natural science, and we all feel proud of the discoveries made by our greatest scientists like Sir C. V. Raman, Acharya Sir P. C. Ray, the late Sir J. C. Bose and others who have won international fame and recognition. Can we boast of the same in the field of Medicine and its basic subjects Physiology and Pharmacology with the single exception of Col. Sir R. N. Chopra who has done admirable work in the field of Pharmacology?

Without any reflection on the achievements of the past and present brilliant workers who have been able to do creditable work in the above fields with limited resources and equipment. I may state and I am sure you will all agree with me when I say that the work carried out so far in the fields of physiology, pharmacology, and medicine in this country is infinitesimal compared with the vast volume of research work that has been and is being turned out in the western countries. Presiding over the 17th session of the All-India Medical Conference in December 1940, Dr. K. S. Ray said, 'The original contribution which the Indian Medical Profession has so far been able to make in the domain of Medicine is very meagre and in consequence the estimation in which our profession is held outside India is not very high.' It is high time that ways and means are devised in various parts of our country for the advancement of medicine and its basic subjects and for turning out a greater volume of research work. India should have to its credit certain outstanding discoveries and should make an indelible mark in the fields of physiology, pharmacology, and scientific medicine, to have its proper place in the comity of nations.

Physiology and Medicine in Ancient India.

In a country like India with its ancient traditions and civilization, one has to refer to the past history of these sciences and estimate how far our present-day knowledge is based on the ancient conceptions and how far progress has been achieved in this country to keep abreast of the times.

The beginnings of Indian Physiology and Medicine are shrouded in mythology, philosophy, and vedic literature. The ancient Aryans claimed to have derived their knowledge from the Gods through direct revelation and it was the practice in Ancient India for persons who were learned and were able to disseminate knowledge of any kind to claim descendency from Gods or claim kinship to the holy sages of Vedic times in order to command sanctity or authority. The people also were ready to invest such persons with sanctity and authority.

Whatever the legendary origin may be, the first propounder of the ancient physiology and medicine in India after the Vedic period appears to have been Dhanvantari who transmitted his knowledge to his disciple Sushruta who lived about fifth century B.C. and who created a science from the confused materials of Vedic origin. The Sushruta Samhita, referred to in Indian Medical literature, was a later compilation based on the original work of Sushruta by Naga Arjuna in the fourth or second century B.C. In south India, Agastya, who lived about the sixth or seventh century B.C. and who is said to have derived his knowledge from Sage Vasishta, is venerated as the first teacher of science and literature to the primitive Dravidian tribes and as the founder of the Siddha system of Medicine. Some say Siddha is only an offshoot of Ayurveda. Charaka Samhita compiled by Sage Charaka about the second century A.D. is said to be a revision of a treatise on Medicine composed by Agnivesa, a disciple of Sage Punarvasu or Atreya. This work is valued for its therapeutical portion and also for its chapters on subjects like destiny, soul, mind, logic, dreams, etc. Later compilations in the succeeding ages down to the sixteenth century A.D. were only commentaries or treatises based on the original works of Sushruta and Charaka. They were: (1) Ashtangahridaya-Samhita by Vagbhata in 625 A.D., (2) Nidana by Sayana, (3) Chakradatta-Sangraha by Chakrapani-datta, and (4) Bhava-prakasha by Bhavamisra in 1550 A.D.

Just as other nations in the world are proud of the achievements of their ancestors and their ancient traditions and literature, so are we of our own traditions and the achievements of our ancestors. We should certainly have the greatest admiration and respect for what our ancient sages or philosophers recorded in this land by their own initiative, acute observation, speculation, and imagination as regards the normal working of the human body, the diseases it is prone to, and the therapeutic measures, about 2,500 years ago when there was supposed to be bankruptcy of thought in many parts of the world, at an age when ordinary knowledge of inorganic sciences was non-existent, and at an age when there was absolute ignorance of the microscopic structure and the chemistry of the tissues and organs of the body. These ancient records are said to have had a profound influence on the origin and growth of the later Arabic and Egyptian Medicine and through them on the later Greek and Roman Medicine which has been the progenitor of Modern Medicine. But we cannot live, progress, and compete with the other nations of the world on only traditions and glories of the past. We must progress in scientific thoughts and correlate our ideas of animal physiology with the rapid advances in our knowledge of physics and chemistry and apply the new ideas for the advancement of Medicine and Pharmacology. Science is international. Established knowledge and findings must be accepted and built upon. Our present and future research must be based on the scientific knowledge obtainable at the present day.

It was very unfortunate that the ancient works of Sushruta and Charaka were regarded by the succeeding generations in India as of divine origin and therefore beyond the criticism of man. There was no attempt at research, at experimental investigation of the dogmatic and empirical statements of the ancient philosophers. There was no addition or modification of the original views but only repetition of the ancient doctrines in a more elaborate form by the later compilers like Vagbhata, Sayana, Bhavamisra, and others. In other words, there has been stagnation and decadence of thought as regards the knowledge of the working of the human body and consequently in its application to Medicine during the last twenty centuries. The chequered history of India, religious scruples, and royal edicts prohibiting the study of practical Anatomy were also contributory causes for this decadence.

With the introduction of scientific medicine in India by the British, the indigenous system of medicine and its basic knowledge of the human body which did not conform to the scientific knowledge prevalent then in the West was severely left alone in its primitive form to be practised by its own advocates who had no knowledge of modern sciences. This led to the perpetuation of the ancient doctrines by hereditary Vaidyans and Hakims who gathered popularity by offering cheap treatment quite empirical in its nature, not only amongst the ignorant masses who form 90% of the population but also amongst the so-called educated who have had no scientific training and who look upon the western medicinal preparations as something foreign and not suitable to their constitutions. To make matters worse, commentators who claim to have studied western medical science have done the greatest harm by fostering a gross misconception among the Vaidyans and the credulous public that all essentials of modern physiology and medicine were described long ago in Ayurveda, that our ancient medical scriptures contain incontrovertible truths which will hold good for all time, that all recent discoveries in Physiology were already known to our ancients, and that the 'tridhatu' theory of Ayurveda can be explained in terms of hormones and autonomic chemical mechanism recently dicovered in the West. Yet others say that Ayurveda is a blending of physiology, metaphysics, philosophy, and psychology and can never be explained by modern material scientists, and that the Ayurvedic physiology begins just where the orthodox cellular physiology of western medicine ends. These interpretations and assertions are mere theorizations without the slightest support by any sort of experimental research work. By these assertions a strong public opinion has been created in the country that Ayurveda is a perfect science and needs no modification or recasting. The public after all are more led away by the cheap treatment and the cures effected by the use of indigenous drugs, some of which are, no doubt, efficacious when administered judiciously, than by the scientific basis of Ayurvedic medicine. This strong public opinion has in recent years developed into a public agitation and clamour in different parts of the country for the encouragement of the indigenous systems of medicine, for the opening up of a large number of Ayurvedic dispensaries, and even for the conversion of the present Ayurvedic schools or schools of Indian medicine run by the Government or private Managing Bodies into Colleges. If this ancient medical literature is left in the hands of unscientific speculators and obscurantists without any effective control or criticism by authoritative bodies, scientific associations, etc., there can never be any progress in Indian Medicine and its basic subjects.

India and possibly China, I believe, are the only countries in the world where an ancient system of medicine based on primitive unscientific conceptions and without any modification is still being practised and supported by the public side by side with modern scientific medicine. It is high time that ways and means are sought by scientific men and bodies and particularly by such an influential and authoritative organization as the Indian Science Congress Association to convince the public and the Managing Bodies of the true position of Ayurveda and establish Indian Medicine on a scientific basis. Acharya Sir P. C. Ray in his address on the Founder's Day of the Calcutta Medical College on the 20th February 1940 said: 'We must now look forward and judge where we stand in the present world which is based on scientific civilization. Although I have referred to Ayurveda, I should say that the policy of passing off the indigenous systems of medicine as scientific systems of medicine after putting a veneer of modern sciences like Physiology and Anatomy on them, does not seem to me to be the correct course. The policy should rather be to accept the western scientific system of medicine as the nucleus round which the tested knowledge derived from the indigenous systems of medicine may be gathered. All our knowledge should be accumulated on scientific lines.' These are most fitting words expressed by an eminent Indian Scientist that should provoke thought in all those who encourage and advocate the teaching of the indigenous systems of medicine. I am glad to find that the *Medical Practitioner*, a monthly medical journal of Madras, has started criticizing rightly the establishment of schools and dispensaries of the unscientific indigenous systems of medicine and quotes the above words of Sir P. C. Ray in support.

A good deal of money and energy is now being spent by the Managing Bodies of the schools set up for teaching the indigenous systems of medicine at Madras, Delhi, Jhansi, Calcutta and other places in India. If only these funds and efforts could be diverted to make these institutions centres of research, centres for pooling all literature, recorded and unrecorded, about the indigenous systems of medicine and about indigenous drugs, centres for the examination, without prejudice, of such accumulated literature in the light of modern scientific knowledge by competent men, and centres for the scientific investigation of the indigenous drugs and for the standardization of those proved efficacious, will it not conduce towards the evolution of one scientific system of medicine and one pharmacopoeia in India? Will not such a procedure impress the public that a serious attempt is being made to investigate the ancient medical literature of the land and to adopt such portions of it as are scientifically proved correct and useful and will it not allay the present clamour for the perpetuation of an antiquated system? Will not such an evolution pave the way for the real advancement of scientific medicine in India and for India to secure a proper place in the scientific world?

As far as the basic physiological knowledge of the indigenous system is concerned, with due respect to our ancient philosophers, it should be considered as only ancient history and should form a part of the History of Oriental Medicine. The 'tridhatu theory' of Ayurveda, in my opinion, is based on a very primitive conception of life. All objects, animate and inanimate, were considered to be formed of five components (pancha bhutas), the earth, water, fire, air, and ether, in various proportions. In the animate the bhutas are said to be in the form of blood, flesh, bones, fat, and marrow. These bhutas are said to be influenced by three forces or tridhatus, vayu, pitta, and kapha or sleshma. When these forces are disturbed they become 'doshas' and cause disease.

'The Upanishads tell us that vayu (air), the universal store of energy and the vital force (prana) are identical.' 'In the physical world it is known as vayu (air), and in the living world as prana (vital force).' The so-called vital force, which was also introduced in the physiology of the West in order to explain ununderstood physiological phenomena, has to a large extent been exploded only during the past half a century by the advanced knowledge of physical chemistry and application of the laws of osmosis, imbibition, adsorption, ionisation, electric potentials, etc. Our ancients living 2,000 years ago were not in a position to explain the nature of this vital force and so conceived of vayu (air) which enters the body endowed with energy as one of the forces which 'radiates and courses through the organs in constant currents and determines the origin, growth, movements, and disintegration of all animated organisms'. Having had no knowledge of fermentation and bacterial action, the primary field of action of vayu was considered, according to Sushruta, to be the intestinal tract and the rectum. The vayu was classified into five different types according to the location in the body. 'According to the Dravidian conception, all movements such as locomotion, laughing, yawning, vomiting, etc., were said to be due to 14 different gases.' Advocates of Ayurveda and commentators have interpreted that the term 'vayu' was intended to mean not only gas or air but also to mean nerve force and to comprehend all the phenomena associated with the activity of the central nervous system and the autonomic nervous system. But there is no mention of 'brain' or 'spinal cord' in Sushruta Samhita to warrant such an interpretation. In later books 'chakras' (whirl-winds), which have been translated as nerve-plexuses, are described as the sources of local forces or energy, in various parts of the body including the skull.

The two other terms, 'pitta' and 'kapha' were originally used, I believe, to indicate 'bile' and 'phlegm'. The ancients, ignorant of their origin, thought that pittam (bile) occupied an area between the stomach and the intestine and that kapha occupied the stomach, the chest, the throat, the head and the joints. They thought that these fluids by permeating all over the body and by mutual interaction accounted for all other changes in the body such as digestion, absorption of 'rasa' (juice from food), excretion of impure matter in the form of urine and faeces, production of heat, and supply of watery elements to keep the system cool, kapha overcoming the effects of pitta and thus contributing to the welfare of the body. Commentators assert that these terms were used in the ancient scriptures with a double meaning, that they not only meant bile and phlegm but also the forces of katabolism (pitta) and anabolism (kapha), and that they also represent the various hormones discovered in recent years.

According to Sushruta, heart was considered to be the seat of cognition (buddhi sthanam) and of emotion. Its action is supposed to be kept up by a special type of pitta (Sadhak pitta). When a man goes to sleep, his heart was considered to be in a state of constriction and unconsciousness and when he wakes up the heart unfolds like the lotus flower. These statements show there was absolute ignorance about the circulation of blood and the action of the heart as a pump and yet the advocates of Ayurveda say that our ancients knew all about the circulation of the blood.

There is no mention of pulse in Sushruta or Charaka. The knowledge of pulse is said to have been derived from the ancient Chinese and developed during the post-Buddhistic period. According to Ayurveda, pulse (nadi) has been interpreted as the result of a harmonious action of the tridhatus and any derangement of one or all the three dhatus is said to be indicated by the nature of the impingement of the pulse-wave on each of the three or all the three fingers used in feeling the pulse at the wrist. The pulsation felt by the fingers was compared to the gait of a peacock, swan, tortoise, frog, snake, etc., and interpreted for diagnosing the disorder. Thus it will be seen that the whole knowledge of pulse is not based on ideas of the physiology of the cardio-vascular system but on sheer observation and experience and association of the variation of rate and force of the pulse with the derangement of the tridhatus.

I have dwelt at some length on these ancient conceptions just to indicate their untenability in the light of modern knowledge. Public opinion is not satisfied by a sweeping remark that Ayurveda is antiquated and unscientific. More elaborate analysis and periodical publications by scientific men and associations are necessary to convince the public of the untenability of the doctrines contained in Ayurveda. This is all the more necessary now because some persons trained in western medicine have started broadcasting that 'the "tridhatu theory" goes many steps beyond the cell of the western cellular theory', 'the tridhatu physiology of Ayurveda begins just where the orthodox cellular physiology of western medicine ends,' and that 'the tendency of modern western physiology appears to be towards a more rational concept of a humoral theory, modified though it may be, from the oldest and most famous ayurvedic concept'. Apparently, the modern discoveries regarding the influence of various hormones in the body and the chemical transmission of impulses arising in the autonomic nervous system are interpreted in support of the old ayurvedic humoral theory. There cannot be a greater travesty of truth. By such interpretations, they are only trying to put new wine into old bottles and put on labels which never existed and which were never thought of by the ancients. These interpreters do not realize that the two guiding principles in physiology, the integrative action of the circulatory system and that of the nervous system, were not understood in ancient India and that physiology is born of an exact knowledge of Anatomy and a correct application of the experimental method. The old tridhatu theory, with the best interpretation possible according to modern concepts, falls far short of the present-day knowledge. If we are to progress, we must take, therefore, the present-day scientific knowledge as the basis and proceed further as no less a person than Sir P. C. Ray pointed out.

Modern Physiology.

Modern Physiology in the West entered on its new phase only in the seventeenth century with the discovery of circulation of blood by William Harvey the real founder of Experimental Physiology, in 1628. It can be said that in the seventeenth century 'one stepped from the ancient into the modern world'. The introduction of the microscope evolved by Galileo Galilei (1564-1642), Kepler (1571–1630), Huygens (1629–95), and the application of the new sciences of physics, chemistry, and mathematics led to the elucidation of physiological problems and a new light was thrown on the physiology of circulation, respiration, digestion, glands and muscles of the body by Malpighi (1661), Richard Lower (1669), Robert Boyle (1660) who was the first to extract blood gases, Robert Hooke (1667), Sylvius (1663) who emphasized the importance of chemical conceptions in Physiology, de Graaf (1671), William Croone (1664), and a host of other workers. It was unfortunate, owing to lack of contact with the western world, these western scientific developments during this century did not affect our ancient ayurvedic humoral theories and there was no stepping into the modern world.

In the eighteenth century, the knowledge of cardio-vascular physiology was further increased by the contributions made by John Floyer (1707–10), Stephen Hales (1677–1761), Von Haller (1708–77), John Hunter (1728–93), William Hunter (1718–83), and Hewson (1774). The digestive action of the gastric juice was first demonstrated by Rene de Reaumer (1752) by experimenting on his pet kite. A revolution in the physiology and chemistry of respiration was brought about by the outstanding discoveries of Joseph Black (1754), Lavoisier (1743–94), Scheele (1771), and Priestley (1771). The beginnings of metabolic studies, of neuro-muscular physiology, and of electrophysiology were all in this century. With all these developments, the knowledge of physiology at the beginning of the nineteenth century was meagre. The following extracts from a summary of physiology published by F. Magendie in 1825 show how meagre the knowledge was. 'We are ignorant of the chemical changes which the aliments undergo in the stomach. There may be fermentation and putrefaction. The bile assists in digestion in a very useful manner but the mode in which this is done is unknown. The chemists do not agree as regards the manner in which oxygen produces a change in the colour of the venous blood. The suggestion that the colouration of the blood is due to iron is now rejected as very doubtful. Legallois infers that the cause of the heart's action is in the spinal marrow. Urine contains several principles which are not found in the blood and in consequence of this, a chemical action goes on in the kidney. What changes occur in muscular exercise we are completely ignorant of. Several organs such as the thyroid, the thymus, the spleen, and the suprarenal capsules have been called glands. The use of these parts is entirely unknown.'

In the history of the progress of physiology, the nineteenth century was a very eventful one. With the introduction of the improved type of the compound microscope, the microtome, the mercurial manometer, the kymograph, the ophthalmoscope, the stethoscope, rapid advance in the science took place and it is said that physiology progressed during this period so rapidly that more discoveries were often made in a year than had previously been made in a generation. The advances in the knowledge of physical chemistry, the discovery of the laws which govern diffusion, osmosis, and thermo-dynamics, the investigation of the properties of crystalloids, colloids, and electrolytes in solution, and the invention of the galvanometer, all these had profound effects upon the physiological progress in this century, Claude Bernard, Carl Ludwig, Weber brothers, Gaskell and others were responsible for most of the discoveries. Liebig, Wohler, and Fischer were the pioneers in the field of biochemistry. Bell, Magendie, Von Muller, Marshall Hall, Gaskell and Langley and latterly Ferrier, Sherrington, and Pavlov who made epoch-making studies in neuro-physiology were all master minds in this century. Claude Bernard, apart from his specific discoveries, did his greatest service to physiology by pointing out that the free life of the higher animals depends on the preservation of the constancy of the internal environment, i.e. the relative constancy of blood sugar, the C_H of blood, the volume of blood, the temperature, the water content, and the oxygen content of the body. He said in 1865: 'It is in the study of these inner organic conditions that direct and true explanations are to be found for the phenomena of life, health, sickness, and death of the organism.' Professor Barcroft elaborates this theme in his recent admirable book styled 'The Architecture of Physiological Function' and concludes that the central nervous system which presides over all the reactive mechanisms, preserves the constancy of the internal environment and thus safeguards the harmonious existence of the tissue cells.

During this century, formation of physiological societies and foundation of journals also helped the progress of physiology. The first journal of Physiology was founded in France by Magendie in 1821, in Germany by Muller in 1834, in England by Foster in 1878, and in the United States in 1898. The Physiological Society of Great Britain was founded in 1876 and the first International Physiological Congress was held in 1889 at Basel.

The foundations of endocrinology were also laid in this century by Claude Bernard (1848–57), Addison, Brown Sequard (1856–58), Schafer (1894), Baumann (1895-96), Howell (1898), Von Mering and Minkowski (1889).

Biochemical knowledge increased towards the end of the century and 'biochemists like Sir Gowland Hopkins saw no reason why further knowledge of the intimate dynamics of living organisms should leave anything over to be explained.'

With the beginning of the twentieth century, Haldane, Barcroft, and others urged that modern physiology should be concerned not only with function but also with the regulating, interacting, or integrating mechanisms of the living organism. 'By this method of enquiry chemical changes which seemed at one time to be relatively simple have proved on closer acquaintance to be of unexpected complexity.' For instance, with the discovery of the phosphorus compounds by the Eggletons in Great Britain and by Fiske and Subba Rao (an Andhra) in the United States, there has been, in the words of Prof. A. V. Hill, 'a revolution in muscle physiology'. According to Prof. Hill, other unknown reactions of considerable magnitude are indicated by the changes in the osmotic pressure. During the last two or three decades, the enormous importance of catalysts, vitamins, and internal secretions as activators of chemical change has been realized. Notwithstanding all these great advances, biochemistry, as admirably expressed in the address of a Cambridge Zoologist

(J. Gray), has not given us all we need to know about a jumping frog.

During the present century so far, the brilliant and epoch-making findings of Sherrington, Pavlov, Dale, Adrian, Fulton, and Cannon and more recently the work of Le Gros Clark, Dusser de Barenne, Eccles, Feldberg, Magoun, Ranson, Rosenblueth, and others have enormously increased our knowledge about the integration of the central nervous system and the nature of the working of the autonomic nervous system which controls and directs all processes in maintaining the medium required by the living cells. The assessment of the rôle played by the hypothalamus is a problem of considerable importance the solution of which is still awaited. Progress is being made in the clarification and interpretation of electro-physiological data by Gasser, Erlanger, Bronk, Eccles, O'Connor, Graham, Lorente de No, and others.

Endocrinology, since the beginning of this century, has grown so overwhelming that one is bewildered at its mass. Rapid and steady progress has been made by workers like Allen, Evans, Hoskins, Robson, Butenandt, Collip, Cushing, Van Dyke, Houssay, Zondek, and a host of others and yet a good deal of uncertainty exists as regards the exact rôle played by the endocrine organs in the body. The pituitary body weighing not more than three-quarter gramme is, in Lord Dawson's words, 'the wonder world of the ductless glands. It presides over the destinies of ourselves and of our descendants'. The physiology of sex glands and of adrenal cortex, the interglandular relationships, the relation between the vitamins and the endocrine organs, the relationship between the autonomic nervous system and the endocrine organs, anti-hormones, etc., all these problems still await elucidation and form a rich field for future research.

I hope the advocates of Ayurvedic doctrines in our country will realize the immense magnitude of the work carried out during the past three or four centuries to arrive at the present-day knowledge, and the magnitude of the work which still awaits to be done by the present and future workers to learn the truth about life and life processes. 'Nature will not yield her secrets on demand, nor can discovery be bought' said Lord Dawson. Our ancient sages, who no doubt were master-minds of the vedic and post-vedic times, could not have said the last word about the life processes and their findings cannot hold good for all time. In Osler's words 'Man can do a great deal by observation and thinking, but with them alone he cannot unravel the mysteries of nature'. With all the wealth of scientific knowledge on the subject we already possess, our knowledge of the truth about living processes is still so imperfect that it requires all the ingenuity of the present and future generations of mankind, to be improved upon. At the International Physiological Congress held in 1929 at Baltimore, August Krogh, in his presidential address, said: 'The evolution of physiological truth is the evolution of life itself upon our planet. Ideas are conceived, facts are elaborated with immense joy and with infinite labour. A large number die without ever coming to the light of publication and of those which are published an appalling proportion sink to the bottom and can only be dug out as fossils from dusty library shelves. Many succumb in controversies with other ideas and facts and a minority only survive in the sense they beget new ideas and give rise to the discovery of new facts. I believe that this enormous waste is on the whole inevitable and bound up inseparably with the difficulties which physiological investigation has to overcome. I look upon controversy especially as one of the chief ways in which truth is approached.' These are apt words which depict the true situation in regard to physiological progress. Increased knowledge only increases our wonder at the puzzling nature of the living organism. Nature baffles man at every stage, however ingenious and intellectual he may evolve to be. So human endeavour and spirit of enquiry persist for all time to know the truth about life.

Apart from the general problems in Physiology which have an important bearing in the practice of medicine and which still require elucidation by further research, there are several special physiological and allied problems affecting a growing nation like ourselves and requiring urgent attention and investigation. These are, to mention a few, the problem of national nutrition, including the chemistry, preservation, and supply of foodstuffs and agricultural research to improve the quality and quantity of foodstuffs; industrial physiology and medicine and methods of prevention of industrial disease; physiological standards applicable to India; pharmacological research with a view to substitute indigenous drugs tested and found to be efficacious in place of imported drugs and ultimately to establish an Indian Pharmacopoeia; pharmaceutical and biological industry and agricultural research for the growth of medicinal plants with a view to make the country self-sufficient as regards the supply of therapeutic agents, vaccines, sera, etc.

NUTRITION.

The subject of nutrition deserves the primary attention not only of each individual to keep up his own well-being and efficiency but also of the State for the maintenance of the health and physique of its people. People who are healthy and physically and mentally strong are an asset to any country. Lack of nutritious food, apart from other causes, leads to a lack of capacity for sustained physical and mental effort, to a spirit of inferiority complex, and to a sense of defeatism. If a nation, therefore, has to progress and win a proper place in the comity of nations either at peace or at war, the efficiency of national diet should be ensured by suitable measures by a central organization. In all progressive countries, research on foodstuffs and measures to ensure a proper food-supply to their nationals are found to have the primary claim on the attention of the State and there is a co-ordinated planning by the specially appointed Ministries of Food, Health and Agriculture to improve the quality and the quantity of food available to the people. Both by State organization and by private endowments, an immense volume of research work is being turned out. Various available foodstuffs are analyzed to find the nutritive values, balanced diets are prepared to ensure the right proportion of proteins, fats, carbohydrates, vitamins, and minerals, and special foods needed by the sick and the infant are made available.

The problem of nutrition in India has not received as yet a fraction of the attention it has received in other countries. The diet in this country which is largely agricultural consists mostly of the cereal grown in the particular areas with a few supplements, the quality and the quantity of which vary according to the economic condition of the people which in 90% of the cases is far from satisfactory. As a consequence, malnutrition and food deficiency diseases are rampant all over the country, particularly in the rice eating areas.

During the past two decades, very valuable work has, no doubt, been done in connection with nutrition and food deficiency diseases, under the auspices of the Indian Research Fund Association, by several workers at Coonoor, Bombay, Calcutta, Dacca, and other places, particularly at Coonoor on a larger scale. The incidence of malnutrition and food deficiency diseases in South India and Bengal has been examined by McCarrison, Aykroyd, Rajagopal, Krishnan, Wilson, and others; with a view to estimate the protein, mineral, and vitamin contents, various foodstuffs have been analyzed by Aykroyd, Swaminathan, Ranganathan, Sundararajan, Giri, Niyogi and his co-workers, Basu, Guha, Ahmad, De, Wilson, Ghosh, Seshan, Mitra, and others; a series of cheap well-balanced diets are being formulated by Aykroyd, and his co-workers at Coonoor, and by Niyogi and his co-workers at Bombay. I need not dwell on the details of the highly creditable work carried out by the above-mentioned workers, as they have already been, very ably, summarized by Col. S. L. Bhatia in 'The Progress of Science in India during the past 25 years', also by Prof. N. M. Basu in his presidential address at the 26th Session of the Indian Science Congress, and in the Annual Review of Biochemical and Allied Research in India, 1940.

There are still several nutritional problems which await solution and there is a vast scope for organized research to be done in co-operation with the Public Health and Agricultural

Departments by a large number of research workers for the improvement of our national diet to suit all classes of people in this country. The actual requirements of a nutritious diet suited to a tropical climate yet requires elucidation and the suitability of all foodstuffs available in the tropics has to be examined more thoroughly. Devising a completely satisfactory cheap diet in areas where rice is the staple food is an urgent and important problem. This problem is now being investigated in great detail by Dr. W. R. Aykroyd and his co-workers. It is a pity that preservation of the full vitamin B_1 and mineral content of rice in the process of milling has not received the attention that is due. It would be a great advantage if suitable pounding machinery or any other type of machinery could be devised and introduced for the production of rice on a large scale with almost all its protein, vitamin B_1, and mineral content. Another practicable and a very useful measure would be the production of rice flour from the milled rice on a large scale and fortifying the same at the source with sufficient vitamin B_1 and calcium, or production of flour from husked rice with its full vitamin content and educating the people to consume such flour in the form of rice-cakes or rice-puddings, at least for one meal during the day. This measure could very effectively be adopted in the Army for such of those Indian troops who are rice eaters. It is also possible by progress in Agricultural research to introduce strains of rice of higher nutritive value. According to the reports from the Imperial Council of Agricultural Research, this has been attempted during the last 4 or 5 years and as a result it has been reported that there is a growing and persistent demand in Assam for improving the paddy seed. It is hoped that this demand will spread all over rice-cultivated areas and the best strains will be available for consumption.

But the problem of rice diet will not be solved by these measures alone. Dr. Aykroyd has pointed out that even the best quality of handpound parboiled rice remains deficient in protein (notwithstanding the high biological value of protein in rice), in fat, in calcium, in vitamin A, and also in nicotinic acid and flavine of vitamin B_2 complex. These constituents are considerably reduced by the process of milling, washing, and discarding the conjee after cooking. Pulses which supply some of these deficiencies should form an important part of rice diet, at least 3 ozs. a day, particularly of the vegetarian rice diet. But the poor man seldom adds this to his diet because of the prohibitive cost. Here again cultivation of the different pulses should be developed by agricultural research and education of the cultivators and the product should be available to the poor at a low price.

Milk is a very valuable adjunct to rice diet to supply the deficiencies. It seems an irony of fate that in a large agricultural country like India, in a country where, according to the recent report made by the Agricultural Marketing Advisor to the Government of India, there is one-third of world's cattle, the milk yield is so very poor that it is not available to the masses in general for consumption. According to the cattle census taken in 1935, there are 230 million of cattle in India, of which only about 65 million cows and she-buffaloes are kept for breeding or production of milk and there is an abundance of ill-fed cattle. Although India has as many milch cattle as the whole of Europe, the production of milk is only one-fifth of that of Europe to serve a population of about 380 millions. Owing to the economic conditions of the people in the rural areas, the milk produced there is passed on to the urban areas and there is nothing left for the villagers' consumption. This deplorable state of affairs can, to a large extent, be remedied by state organization, veterinary research, and agricultural improvements to increase the area of pasture land and fodder for the cattle. A knowledge of the problems of animal husbandry should be made available to the farmers all over, the cattle strains should be gradually improved and by selective breeding the milk yield should be increased to such an extent that an ordinary villager is able to secure some milk at a reasonably low cost. By increasing the milk supply, the malnutrition prevalent now would be reduced to a very large extent. A large number of Government and private dairy farms should be established in various parts, adulteration and contamination of milk should be prevented, and the marketing of milk should be well organized.

Milk products such as curds, buttermilk, and ghee are extensively used in India and form valuable supplements to rice or wheat diet. It is very seldom that one can get really pure unadulterated ghee from the market. There is no other foodstuff which is so deliberately adulterated with impunity in India than ghee. An efficient supply of pure ghee can be ensured only by periodical inspection both at the source and at the retail shops by the State authorities, by chemical analysis of samples taken at the time of inspection, and by imposition of very severe penalties on the offenders. Arrangements for distribution in hermetically sealed cans to prevent adulteration and contamination are also desirable. Biochemists should be of help in devising methods of preparation and storage of ghee in large quantities to prevent early onset of rancidity.

There are several other food-supply problems demanding the attention of the scientists and marketing organizations. Eggs form an important source of proteins of high biological value and of vitamins A, B_1, B_2, and D. The production and supply of such an important foodstuff has not received the attention it deserves. It has been estimated that there is annually a total avoidable loss of eggs worth about Rs.57 lakhs in this country by inefficient methods of storage in hot weather, lack of proper transport facilities, breakages and losses on account of bad housing or no housing of the fowls, and by epidemics prevalent amongst the fowls. The Government Livestock Departments should come to the rescue in this matter and should do extensive propaganda and demonstrate to the people concerned the right methods of poultry breeding, the selection of improved varieties of poultry suited to Indian conditions, and the proper ways of collection, preservation, and transport of eggs. It was reported not long ago that the Baroda State adopted a scheme to train selected candidates and provide them with sufficient capital to start small poultry farms. In Bombay an Inspector of the Agricultural Department has been recently appointed specially to advise villagers on the starting and working of poultry farms. In South India, poultry farms have been started only in three or four villages and a Co-operative Egg Production and Marketing Society at one centre. It is hoped that these measures will be copied all over India.

Fish is another cheap source of animal protein of high biological value and also a source of calcium, phosphorus, and iron. In Bengal, Guha, Chakravorty, Ghosh, Basu, Gupta, and others, in Madras De, Majumdar, Sundararajan, and Seshan, and in Bombay Niyogi, Patwardan, Acharya, and Chitre have investigated the nutritive value of several varieties of fresh-water fish and sea fish available in those quarters and have shown that they provide a rich source of protein of high biological value and minerals. They have also found that the liver oils of some of the varieties of fish were considerably richer in vitamin A than average cod-liver oil. If only fishing industry in India could be improved and efficient methods of catching fish are adopted, the yield could be increased enormously and fresh fish could be made available in larger quantities by proper transport and refrigeration to all classes of people and thus better nutrition can be provided for.

Vegetables and fruit are valuable food materials which require special attention, as they supply important food factors, particularly vitamins A and C and minerals. Demonstration fruit and vegetable gardens should be established by the Agricultural Department and improved strains of seeds of vegetable and fruit plants should be distributed on a large scale and growth promoted by the introduction of improved methods of manuring and cultivation. Private nurseries should be encouraged and canning of selected strains of fruit at suitable places should be started. It is gratifying to learn that the existing canning factories are to be developed by the Government and used for the manufacture of jam, marmalade, canned tomatoes, dehydrated potatoes and vegetables.

Malting of cholum, ragi, rice, etc., is another industry which should be encouraged. Malted food would not only be useful for local consumption by invalids and infants but also for export to foreign countries if prepared on a large scale. This industry has just been started as a cottage industry, with the advice of the Development Department, in one district in South India and it is hoped it will spread widely all over India.

Imparting dietary advice to the people in general by the issue of pamphlets on adequate diets, and arranging series of talks at meetings or on the radio as to what people should eat and why, and as to what they can buy for a certain sum of money, are also necessary measures to educate the public and help them to adopt the most nutritious diet which they can afford to secure.

Industrial Physiology, Hygiene, and Medicine.

War has given a fillip to the growth of Industries in India. With the marked growth of Industries, the problem of Industrial Physiology, Hygiene, and Medicine should necessarily engage the attention of the State and the private Managing Bodies and there should be a greater demand for the services of medical men and research workers to conserve the health of the workers, to reduce the frequency and severity of disabilities induced industrially and to devise protective measures to safeguard against toxic agents, etc.

In the interest of production, both as regards the rate and the quantity, the physiological factors such as the muscular effort involved and the proper selection of the operatives according to their physical fitness, the effects of environmental conditions such as temperature, humidity, lighting, noise, dust, etc., on the workers, the duration of work in relation to the severity of the work and prevention of excess of fatigue, avoidance of postural strain in light work such as shoe-making, hosiery work, etc., and overcoming the effects of such strain by the introduction of physical exercises during the working hours as is done in Russia, all these require attention and investigation. A high level of physical and mental fitness of the workers should be maintained by insisting on suitable exercise, by instructing the employees about healthy living, and by improving the ventilation and sanitation in factories, workshops, mines, etc. Investigation of occupational diseases and of the relative toxicity of materials and introduction of a course on Industrial Hygiene and Toxicology in Medical Schools and Colleges also deserve consideration.

Physiological Standards.

The determination of physiological standards in a vast country like India with its tropical climate is of great importance for the assessment of the health and physical fitness of the people. Environmental factors have a profound influence on the human organism and 'man is considered a mere creature of his meteorological environment'. Studies have already been made to a certain extent in the various parts of India on the haematological standards, blood-pressures, vital capacities, gastric acidity, blood-sugar curves, and basal metabolic rates. I need not go into the details of these studies as they have already been summarized in 'The Progress of Science in India during the past 25 years' and also in the previous presidential addresses, nor should I dwell on this subject longer as it has been discussed most elaborately by one of my distinguished predecessors, Col. Sir R. N. Chopra in his most illuminating presidential address on 'The physiology of the individual in the tropics' delivered at the Jubilee Session of the Congress in 1938. It may suffice if I just quote here his concluding remarks which are highly significant. He concluded his address by saying 'If these environmental factors are studied in greater detail, particularly with reference to the changes that they might produce in the human organism, a new branch of physiology may be developed in this country. The material is in abundance; but it needs the sickle of properly organized and directed research to garner a harvest which will be of the greatest value to us in India as well as to the world at large.'

Pharmacological Research.

For the growth of Medicine in India, there is no other subject which is of greater importance than pharmacological research. The literature on indigenous drugs which is the legacy of several centuries based on experience and keen observation provides a rich field for fruitful investigation. The Indian Materia Medica consists of drugs handed down from the time of Rigveda, i.e. 4500 to 1500 B.C. and the Rigveda itself mentions the names of 1001 medicinal drugs. The really valuable chapters in Sushruta and Charaka are those on Therapeutics (Chikitsasthanam) and those on the medicinal properties of plants, minerals, animal substances, poisons, and antidotes. Here we find an elaborate description of the therapeutic properties of natural products: herbs and minerals, waters of different rivers, milk of different animals, flesh of carnivorous animals, etc. In his review of Indian Pharmacology in 1894, Kanai Lal Dey observed as follows: 'The elaborate directions for the collection of drugs and their subsequent manipulation show the great progress which the ancient Hindus had made in the healing art. Minute instructions were given, strange as they may seem to us now, on every conceivable point such as the gathering of herbs, preparation of medicines, etc. Annual plants were to be collected before the ripening of the seed, biennials in the spring, perennials in the autumn; twigs were to be of present year's growth, the roots to be collected in the cold season, the leaves in the hot season, and the barks and the wood in the rains. Many of the preparations were crude enough in their exhibition but wondrously efficacious in the respective ailments for which they were designed.' The ancient Hindu medicine is said to have reached its perfection in Buddhistic times and its influence spread far and wide into Arabia, Egypt, Greece, and Rome. But this glory was only short-lived. It began to decline at the time of the Mohammadan invasion of India as it had to compete with the Unani system which developed as the State Medicine and later, with the fall of the Moghul Empire, there was further decline and intermingling to a certain extent of the two systems. In spite of the growth of the western scientific system in India during the past 250 years and its gradual spread along the length and breadth of the land by the opening of Medical Schools and Colleges, numerous hospitals and dispensaries, these two ancient empirical systems, Ayurvedic and Unani systems, are still living systems and provide remedies to about 90% of the population in India. The scientific system of medicine has not yet become popular among the masses to the extent it ought to have, because of its costliness and unavailability in the remote villages and also because of the appalling poverty and ignorance of the people. As stated by Dr. A. D. Mukerji in his presidential address at the All-India Medical Licentiates' Conference in December 1940, the whole country has only 6191 centres of medical relief, i.e. one centre for a population of 50,000 to 60,000 and there are about 35,000 qualified medical practitioners in India, i.e. one for a population of 10,000 as contrasted with one for 800 persons in England. In order to bring the scientific system of medicine and the tested efficacious drugs within the reach of the villager, many more dispensaries will have to be opened and the medicinal drugs should be made available at a very low price. The problem of increasing the quantity and quality of the essential drugs can never be solved by mere importation of drugs from foreign countries. If only the resources of this country are fully mobilized and utilized, there is no need for such importation at all on a large scale. Nature always provides in each country medicinal herbs and other products which if judiciously used serve well as remedies for most of the illnesses prevalent in that country. In a vast country like India with its numerous long ranges of hills and valleys and large tracts of fertile land and with a remarkable variety of climatic conditions, every medicinal plant of any importance should be cultivable. Col. Sir R. N. Chopra, the great pioneer in pharmacological research, in his admirable and most useful treatise on 'Indigenous drugs in India' published in 1932, rightly says: 'Nearly three-fourths of the drugs mentioned in the British and other Pharmacopoeias grow here in a state of nature. It is possible that the drugs which do not naturally grow within her bounds could be easily made to do so.

'Standard pharmaceutical preparations and active principles of a large number of pharmacopoeial drugs could be prepared in India probably at a low price. A serious attempt has to be made now to make India self-supporting by enabling her to utilize the drugs produced in this country and by manufacturing them in a form suitable for administration.'

It is very gratifying to note, in this connection, that owing to war conditions and consequent difficulty in obtaining pharmacopoeial preparations, active measures have now been taken by the Government of India to mobilize the drug resources of this country and according to a recent publication by the Government of India, every drug for which basic materials are available in this country is now manufactured here. Before the war, as many as 411 items of drugs were imported from abroad, many from Germany, while only 123 items were produced locally. The latest position is that as many as 292 items are manufactured here while 242 items are still imported. Except for a few synthetic products and proprietary medicines, the problem of finding substitutes for the rest of the imported drugs could be solved if only valiant efforts are made to investigate all the drugs used by the indigenous practitioners. If the systems of indigenous medicine are shed of their ancient physiological and pathological doctrines which form only ancient history, what is left will be the Indian Materia Medica and Therapeutics. It is this part of the indigenous medicine which requires a thorough investigation. There are, according to reports from the public and the indigenous practitioners, many indigenous drugs that act as specifics in certain illnesses, but as the indigenous treatment is mostly empirical, a systematic scientific investigation is necessary with a view to separate the really efficacious drugs from those which are of no value and to isolate and to standardize the active principles of selected ones by chemical and biological methods of assay. The question whether the drugs in the form of fresh juices, decoctions, and preparations obtained by special methods of incineration, are more efficacious than alcoholic and purified extracts as contended by the ayurvedic practitioners, has also to be investigated. The magnitude of such work is immense and would keep engaged an army of research workers for decades to come. Well-equipped laboratories should be established at several suitable centres for organized research work to be carried out by teams of workers composed of expert Botanists, Chemists, Pharmacologists, and experienced physicians. As mentioned in the earlier part of my address, the funds and the energy now being spent for teaching the indigenous systems of medicine at Madras, Delhi, Jhansi, Calcutta, and other places should be diverted to establish such centres of research and equip them fully for the purpose of testing all indigenous drugs in the light of modern scientific knowledge without prejudice. If only such an organization could be brought about and controlled by a central research council, there is no doubt that a really comprehensive Indian Pharmacopoeia can be established at an early date, India can be made self-sufficient in regard to drug manufacture and supply, and the problem of having one scientific medicine and one scientific method of treatment can be solved.

Attempts have been made since the beginning of the nineteenth century to collect information about the indigenous medicinal plants by various workers like Jones, Flemming, Roxburgh, Waring, Mohideen Sheriff, Warden and Hooper, Watt, and more recently by Kanai Lal Dey, Kirtikar, Basu and others. The Indigenous Drugs Committee under the able leadership of Col. Sir R. N. Chopra did very useful work by obtaining authentic specimens, making standard preparations, and encouraging their use in Government Institutions. Col. Chopra himself who has won international recognition as an eminent Pharmacologist has been carrying on with his trained workers highly creditable research work on indigenous drugs at the School of Tropical Medicine, Calcutta, since 1921, and has been able to find among the indigenous drugs investigated, drugs which are of value as good expectorants, antispasmodics, diaphoretics, diuretics, and nerve sedatives; drugs which are of benefit in diabetes mellitus, tubercular affections, ascitis, amoebic infections of the bowel and leprosy. In his admirable book on 'Indigenous Drugs of India', he has discussed threadbare the various medical and economic aspects of the indigenous drugs and the problems that have to be solved before a really comprehensive Indian Pharmacopoeia can be formed. At the Pharmacological Research Unit of the Madras Medical College, Dr. K. Venkatachalam has examined the therapeutic value of a large number of reputed indigenous drugs and has found a remedy which is as effective as santonin for expelling round worms, two new stable and non-toxic alkaloids with a typical digitalis like action on the heart, two alkaloids with the same action as that of emetine, and a cheap and efficient drug (*Cassia fistula*) which acts as a specific in Blackwater fever. He found at the same time that a number of drugs claimed as remedies for diabetes, cholera, and leprosy possessed none of the merits attributed to them. He has also been carrying on, by a special research grant from the Imperial Council of Agricultural Research, investigations on certain herbs said to be toxic to cattle. At the Haffkine Institute, Bombay, Sokhey and Dikshit have made important contributions to the pharmacology of sulphanilamide derivatives and found sulphathiozole to be a very effective remedy against bubonic plague. They have also prepared a specific for malaria and named it haffkinine (acriquine) which is identical with atebrin. It is desirable that this Institute should also undertake investigation of indigenous drugs to a certain extent. The work of analyzing all the available indigenous drugs, said to be about 2,000 in number according to Col. Chopra, and isolating those of real therapeutic value is of such a colossal magnitude that two or three laboratories with limited staff for the whole of India are far too few to produce any substantial results within a reasonable and a measurable period. It took 20 years for the Tropical School of Medicine, Calcutta, to isolate a few useful drugs out of 200 examined. At this rate the problem of establishing an Indian Pharmacopoeia and of supply of indigenous drugs of value will not be solved even for another century. I would, therefore, appeal to the Government, the Universities, and the various managements supporting Medical Schools and other institutions and interested in modern scientific medicine to afford all facilities in their laboratories by equipping them with the necessary staff and equipment for undertaking the investigation of indigenous drugs, on the same lines as are at present adopted at the School of Tropical Medicine, Calcutta, and at the Research Unit, Madras Medical College. The two above-mentioned units may be made the training centres to produce a number of workers in this field and the staffs and the equipment of the units may be strengthened for carrying on the investigation on a more elaborate scale.

In the preparation of the Indian Pharmacopoeia which should include all the British pharmacopoeial drugs prepared from local resources, the substitutes available in this country for the rest of the drugs imported at present, and also other reputed indigenous drugs which have been thoroughly tested and found to be efficacious, it is desirable that along with the botanical or chemical or British pharmacopoeial names, the names of the drugs in the Indian languages in colloquial use or mentioned in Ayurvedic or Unani literature are also retained in order to popularize the use of the tested indigenous drugs and to cause satisfaction in the minds of the public that a really serious attempt has been made to revive the indigenous drugs after testing them scientifically. Such a revival will, to a large extent, allay the present clamour for the encouragement of indigenous medicine and for the opening of more ayurvedic schools and dispensaries.

If the scientifically tested drugs are to be within the reach of the poor masses who are plentiful in this country, apart from the free dispensing in hospitals and dispensaries which will have to be opened in much larger numbers than they are at present, the cost of the medicinal preparations will have to be very much reduced. No doubt, there will be some reduction in price by manufacturing the drugs locally with cheap labour available in this country, but the reduction will be greater if the expedient of supplying crude preparations in the form of powders, tablets, expressed juices, decoctions, infusions, medicated ghee or oil, syrups, etc., could be adopted. At any rate, for some time to come, owing to the low economic condition of the people, it is desirable that two types of medicinal preparations, one high-priced and pure and the other low-priced and crude, should be made available in this country.

In order to make the scheme, of collecting all indigenous drugs in use in India and the literature bearing on them, successful, local centres should be established in each district where every practitioner of indigenous medicine, qualified or unqualified, of that district should be asked to report and deliver to the Medical Officer in charge of the district samples of the remedies he employs for various illnesses and a written account of the methods of preparation of his remedies, the areas from which he obtains his medicinal herbs or minerals, and all available information pertaining to the drugs. No indigenous practitioner should be allowed to dispense a remedy, the composition of which he does not reveal and a sample of which is not sent to the Local Indigenous Drug Centre. The Medical Officers of these Local Centres should be held responsible for the transmission of the collected specimens and the literature bearing on them to the nearest Research Centre. At the Research Centres, proper investigation and standardization of the useful drugs by suitable experts should be carried out and periodical bulletins and publications should be issued regarding the efficacy of the tested drugs, their doses, etc., for the benefit of the medical practitioners, and in order that further clinical trials may be made and the merits of the drugs may be established. The carrying out of such a scheme would require State organization and levy of penalties on such of the practitioners who do not comply with the provisions of the scheme.

Pharmaceutical and Biological Industry in India.

If India is to become self-supporting in regard to the supply of all pharmacopoeial and proprietary preparations, synthetic drugs, and various biological products, such as endocrine principles, vitamin preparations, vaccines, prophylactic anti-sera, etc., private industry should be encouraged and protected by the Government and the present Government Medical Store Depots should be enlarged and multiplied. A few private firms such as The Bengal Pharmaceutical Works, The Bengal Immunity Co., The Alembic Chemical Works Co., Ltd., Baroda, The Continental Drug Co., Bombay, The Mysore Government Industrial and Testing Laboratory, Bangalore, etc., have sprung into being during the past decade or two and have been sources of supply of various pharmacopoeial and proprietary medicines and also a few ayurvedic drugs in the form of tinctures, alcoholic extracts, tabloids, etc. With the expansion of indigenous drug research and the increased knowledge of their therapeutic value, it is hoped that these firms will take to indigenous drug manufacture on a larger scale and a larger number of firms will come into existence. The war has already given a great stimulus to this industry and the Government has mobilized all industrial talent in this country to reduce the number of imported drugs as far as possible. Anaesthetic ether is being turned out at the rate of 10,000 lbs. per month and some essential oils, chloroform, atropine sulph., caffiene from tea-dust, sodium citrate, boric acid, chloral hydrate, antiseptics, vitamin preparations, etc., all formerly imported are now produced here. Considerable headway has also been made in the manufacture of surgical instruments, scientific apparatus, rubber articles such as hot water bottles, cushions, corks, tubing, etc., glass ampoules for biological products, sterilized catgut, surgical dressings, etc. For the growth of pharmaceutical industry, organization is also needed for the supply, on a large scale, of chemicals and solvents, such as benzene, chloroform, petroleum ether, acetone, glycerine, etc., and also appliances such as vacuum stills, percolators, tincture presses, autoclaves, tablet machines, etc. Organization is also needed for the collection of all raw material required for this industry and for the cultivation of the selected medicinal plants both indigenous and of foreign origin on suitable soil on a commercial scale. By scientific methods the raw material which this country possesses in great abundance could be multiplied to such an extent that it can even share it with the rest of the world.

For the supply of necessary trained men, study of pharmaceutics, pharmacognosy, pharmacology, bacteriology, etc., should be encouraged by the Universities and other managing bodies by instituting special degrees and diplomas in those subjects. The Madras and the Benares Hindu Universities now grant B.Sc. Pharmacy degree to those who, after passing Intermediate, undergo a course in General and Organic Chemistry, Natural Science, Physiology, Pharmaceutics, Pharmacognosy, and Pharmacology. It is hoped that other Indian Universities will follow this example. An organized and registered profession of Pharmacy in India should be maintained so that no untrained person can manufacture, dispense, or sell medicines.

Manufacturers should be supplied periodically with a list of new therapeutic agents found efficacious by the research units so that preparations of such agents may be placed readily on the market. Close collaboration should exist between the manufacturers and research institutions and each firm of any magnitude should have a research laboratory attached to it to ensure the maintenance of the requisite standard of the products and for further search for other remedies of therapeutic value. The Indian Pharmacopoeia to be compiled, after its completion, should be revised every 5 or 10 years as is done in all western countries to include newly discovered remedies and to reduce the number of drugs found by experience to be of less value or having similar active principles.

Control should also be exercised over drugs both imported and of Indian manufacture with a view to maintain uniform standards of strength, purity, and quality for drugs. This control could be exercised by the appointment of public drug analysts in all provinces and instituting a central laboratory for co-ordinating their activities. On the recommendation of the Drug Enquiry Committee in 1930, the Biochemical Standardization Laboratory was established for the first time at Calcutta in 1937. Since its establishment, very valuable work has been carried out at this Laboratory by the Director, Col. Sir R. N. Chopra, and his assistant, Dr. B. Mukerji. 'There seems little doubt that the Biochemical Standardization Laboratory has filled a definite gap and removed a long-felt want in the medical and public health administration of the country,' says Col. Chopra in his first report. Now that the Indian Drugs Act, 1940, has been passed by the Government of India, it is hoped that the present Laboratory at Calcutta will be enlarged into a central drugs control Laboratory to co-ordinate and correlate the work of similar laboratories which should be set up in all major provinces. These laboratories should also have pharmacological and pharmaceutical sections for testing and standardizing indigenous drugs. All manufacturers, importers, and traders in drugs should be registered and Government Inspectors should be appointed to collect samples for testing.

Measures necessary for promoting and organizing research in India with a view to improve national nutrition and Indian Medicine.

There should be separate Ministries of Food, Health, Industries, and Agriculture, Central and Provincial. These Ministries should be helped by Scientific Advisory Bodies composed of specialists in each branch and special Councils such as Council of Food and Nutritional Research, Council of Drugs and Medical Research, Council of General Scientific and Industrial Research, and a Council of Agricultural Research. There should be a planned programme in each section for 5 or 10 years with co-ordination and correlation of the activities of the various councils.

Total research grant should be increased by the Government as there is a clear need to increase the provision for research. Larger sums should be placed at the disposal of the Indian Research Fund Association or special grants should be made to certain institutions. Private benefactions should also be sought. In this connection, I may state that the country owes a deep debt of gratitude to the late Sir Dorab J. Tata for having created the Lady Tata Memorial Trust in 1932 with an endowment of Rs.25 lakhs for research on blood diseases and on any problem having a bearing on human suffering. This trust can afford only 5 scholarships of Rs.150 each per month. Such scholarships should be multiplied many times if India has to make any headway in research. I appeal to all well-to-do philanthropic gentlemen in the country to establish such scholarships and studentships by bestowing munificent endowments in different institutions and encourage and promote research talent among the capable young men in this country. A scheme should also be devised to ensure security of tenure for the workers in research laboratories.

Universities in India should play an important part in the promotion of research. It has been said that research is the weakest side of the activities of our Universities in India and by placing an excessive stress on examinations they have failed to kindle, among the students in general an eagerness to know and discover. The Government and the Universities, apart from instituting a large number of research studentships and fellowships, should afford all facilities for more intensive research work in all their institutions teaching chemistry, natural science, physiology, biochemistry, pharmacology, pharmaceutics, bacteriology, and medicine by providing well-equipped laboratories and special research assistants. These research posts would be an attraction to all post-graduate or under-graduate research workers. An impetus to research work could be given by making promotions and crossing of efficiency bars in all the science departments dependent on not only satisfactory routine work but also on some sort of research work and also by offering earlier promotions and crossings of efficiency bars on carrying out any meritorious research work. By encouragement of this kind, a research atmosphere will be created in every institution and research work will be increased in different spheres both in quantity and quality.

Last but not least important measure is the introduction of elementary biology, physiology, and hygiene in the curricula of studies in secondary schools. This measure will go a long way to educate the public in matters of sanitation and personal hygiene and make them co-operate in solving the problems of national nutrition, prevention of disease, adoption of scientific medicine and therapy, and abolition of quackery, charlatanism, and witchcraft.

Concluding Remarks.

In conclusion, I may say that the ultimate aim of all these scientific efforts is mitigation of human suffering and prolongation of human life. All those who work towards this noble cause reflect honour and credit not only on themselves but also on the profession to which they belong. For young workers of discernment, initiative, and the will to do, plenty of opportunities exist in the fields of physiology, nutrition, pharmacology, pharmaceutics, medicine and therapeutics, which all go to fulfil the noble cause. In order that progress may be achieved in the above fields, the fire of ambition must continue to burn in the youth of this country and they must always bear in mind that they are dealing with 'not with an established science but with a practical art, an applied science, and an experimental science, alive not static, a process not an event, begun not finished'. Workers in this noble cause will do well to remember the words of Albert Pike, who said, 'What we have done for ourselves dies with us, what we have done for others and the world remains and is immortal.'

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SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE

President :—GOPESWAR PAL, D.Sc.

Presidential Address

(Delivered on Jan. 5, 1942)

MEASUREMENTS IN PSYCHOLOGY

(i) INTRODUCTION

One of the essential conditions of the progress of a science is the development of the means of improving its method of observation. The great forward step that has lately been taken by psychology lies in the introduction of systematized experimental methods in the field of its observation. Scientific experiments are not regarded as perfect and reliable unless the observed phenomena are quantitatively measured and the growth of quantitative psychology in the recent past promises to fulfil that condition. It is, I believe, to this newly acquired ability of ours to find out how much of a quality under investigation there is in a totality of experience that we owe all the recent advances in our knowledge of mental facts. The importance of quantitative estimate of observed phenomena has been aptly emphasized in the following words of Thomson: 'When you know what you are speaking about and can express it in numbers you know something about it, when you cannot express it in numbers your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge but you have scarcely in your thoughts advanced to the stage of science'.

It is with a view to take stock of how far we have been able to proceed in the task of measuring mental phenomena and with what degree of success that I have chosen this topic as the subject of my address.

It is quite evident that before we proceed to measure an observed phenomenon we must be sure that it really has a quantitative character. A phenomenon which can be expressed in terms of a unit is regarded as quantitative. The length of an object is a measurable magnitude, it can be measured in terms of units, viz. centimetres. The total magnitude is regarded as a multiple or submultiple of the unit. The weight of butter is a quantity, it is measured in terms of the unit gram. We are all familiar with physical magnitudes, their measurements and their units. But are there psychological magnitudes which can be measured? And if so, what are the units of measurement?

(ii) Fechner's concept of measurement of sensation

It was G. T. Fechner who first maintained that psychical phenomenon of sensation-intensity might be regarded as the sum of a number of small sensation-units exactly in the way an hour is taken to be composed of seconds. The unit chosen was the Just Noticeable Difference of Sensation (j.n.d.). Fechner assumed that the just noticeable differences at different levels of intensity of a particular sensation are all equal and hence are suitable units for measuring sensation-intensities. Supposing a sensation-intensity S_2 is found to be just noticeably stronger than the sensation-intensity S_1, then S_2 may be regarded as equal to S_1+1 j.n.d. Similarly when S_3 is found just observably greater than S_2 it may be taken as equal to S_2+1 j.n.d. and so on.

The concept of just noticeable difference of sensation as a unit did not, however, actually originate with Fechner. He got the cue from Weber's experimental results.

E. H. Weber, professor of anatomy in the University of Leipzig, conducted a long series of experiments with lifted weights from 1829–1834. His investigation consisted in determining what amount of weight could be added to a standard weight so that the difference between the original and the increased weight might be just noticeable. He found that for a weight of 32 drams the average just noticeable difference for four persons who had participated in his experiments was 3 drams and for a standard of 32 ounces the difference was not 3 drams but 3 ounces. In other words, the stimulus-increase for just perceptible difference was not a constant amount but was a constant portion of the weight lifted, i.e. $dR/R = c$, where dR is the stimulus-increase for just noticeable difference, R is the stimulus or the standard, and c is a constant to be determined experimentally.

Weber also obtained similar results in the field of visual distances. A line of 101 mm. could be just distinguished as longer than one of 100 mm., while a line of 50·5 mm. was judged to be just noticeably longer than one of 50 mm.

On the basis of these results Weber formulated a general relation which may be thus expressed: In comparing one object with another we perceive not the actual difference between the two objects but the ratio of this difference to the magnitude of the standard that is being compared.

Fechner with his mathematical mind discovered the rudiment of units of mental measurement in Weber's findings. Accepting Weber's equation $dR/R = c$ as fundamentally correct, Fechner transformed the former's experimental discovery of relation into a general form and interpreted it as a functional relation between the body and the mind. How he did that will be made clear by an example.

If a 110 gram-weight is found experimentally to be just heavier than a 100 gram-weight, then, according to Weber's relation, 121 gram-weight will be just noticeably heavier than 110 gram-weight and 133·1 gram-weight will be just heavier in comparison with 121 gram-weight and so on. Fechner assumed that the sensation S_2 corresponding to 110 gram-weight was just perceptibly greater than the sensation S_1 corresponding to the 100 gram-weight and the sensation S_3 corresponding to the 121 gram-weight was just greater than the sensation S_2; similarly, the sensation S_4 corresponding to the 133·1 gram-weight was just noticeably greater than the sensation S_3 and so on with regard to other sensations corresponding to different weights.

Fechner considered S_2 as greater than S_1 by one just noticeable difference in sensation (1 j.n.d.), S_3 as greater than S_2 by one just noticeable difference, and so on. Furthermore, he thought S_2 as equivalent to S_1+1 j.n.d. and $S_3 = S_2 + 1$ j.n.d. $= S_1+2$ j.n.d's. Behind such statements was the assumption that all j.n.d's at all levels of intensity are equal in sensation value.

A weight of 100 grams when placed on the pan of a balance causes deflection of the needle, say, to 10 scale marks. On adding 10 grams to the original weight let us suppose that the needle is further deflected by one mark and we find the total deflection to be 11 marks. If 10 grams more weight are added, the needle moves away over another scale mark. Taking this as an analogy we may say that, according to Fechner's conception, when a 100 gram-weight is placed on the palm of the hand the mental balance records a sensation S_1. On placing 10 grams more the mental balance records one j.n.d. over and above the sensation S_1. Unlike, however, the physical balance of our example the mental balance on the second occasion would not record one j.n.d. until 11 grams more have been added to 110 grams. For recording the next j.n.d. at the third time the mental balance would require an addition of 12·1 grams. Fechner concluded that when the stimulus increases from 100 to 110 grams, then to 121 grams, and then to 133·1 grams, i.e. each time by one-tenth of the standard or, in other words, by equal ratios or in geometrical progression, the sensation increases by equal steps of one j.n.d. unit, i.e. in arithmetical progression.

This conclusion Fechner expressed in the well-known mathematical form which is usually put as $S = c \log R$, where S is the sensation, R the stimulus and c a constant determined experimentally.

(iii) Later conception of measurement of sensation-distance

Fechner's conception that sensation-intensity is a multitude of small units of intensities was very adversely criticized by many later psychologists and it had to be ultimately given up. In the opinion of the critics sensation-intensity is not a multitude and it is not divisible; every sensation is qualitatively different from every other sensation. What we usually consider to be an intensity difference is really a qualitative difference. Fechner's conception of j.n.d. was also subjected to severe criticism. The just noticeable difference in sensation is supposed to have been a datum of direct observation by Fechner but other psychologists[1] especially those who worked with sensation-intensity failed to detect the j.n.d. as such in their introspection. One sensation may be perceived as different from another but no sensation can be psychologically said to be *just* noticeably different from another. 'No sensation wears upon its face a *just* noticeable difference.' Just noticeability is not, as it seems at first, a matter of direct observation, it is an inference or an assumption. It is therefore a theoretical or an abstract concept.

Moreover Fechner's idea of the equality of the j.n.d. at different levels of intensity led to a tremendous controversy. Several experimental investigations have been made with the expressed purpose of testing the equality of the j.n.d's. A series of stimuli values corresponding to eight successive j.n.d's of sensations are determined and then the total 'sensation-distance' is divided into two halves so that each half consists of the distances covered by four successive j.n.d's. These two halves are then compared. If the sensation-distances corresponding to the two halves are found to be equal in introspective experience, the j.n.d's may be regarded as equal.

Experiments conducted by Angell and Ebbinghaus confirmed the equalities of the j.n.d's but other investigators obtained conflicting results. At the present moment we are not certain if the j.n.d's are equal. The question remains an open one.

Measurement of sensation-intensity, notwithstanding the difficulties mentioned here, is not, however, entirely impossible. Given different sensation-intensities, S_1, S_2, S_3, etc., it is possible to grade them according to their intensity values. Moreover according to some observers, given two sensation-intensities, S_1 and S_2, it is quite possible to find another S_3 so that S_3 appears to be as much more intense than S_2 as S_2 appears in comparison with S_1. The disparity between S_2 and S_3 can be directly compared with the disparity between S_1 and S_2. This degree of unlikeness can be represented in other parts of the intensive scale and may be regarded as the unit of measurement in place of the j.n.d. These units are, as a matter of fact, data of direct observation whereas the units of j.n.d. are not so directly apprehended.

This view of mental measurement in terms of sense-apartness or sense-disparity first originated with J. R. L. Delboeuf (1878) and it was Ebbinghaus who first made experiments with light intensities using 'equal appearing sense-distance' as the unit of measurement. This view has been supported by Wundt

Stumpf, James, Müller, and others, some of whom happened to have been bitter critics of Fechner's conception. But here again we are not sure whether the 'equal appearing intervals' at different parts of the intensive scale are really equal or not, or whether a given sense-distance can be equated as a multiple of a unit sense-disparity.

After a long and extremely acute discussion, in which the fundamental logic of measurement of physical magnitude was analyzed and compared with that of psychological measurement, it has been now generally agreed by the majority of the psychologists [2] that sensation-intensities and their differences are at least 'magnitudes' that can be graded. Careful grading of a large number of intensities as also of their differences may ultimately lead to their spacing out in such a way as almost to correspond to their true positions in the scale of intensities.

(iv) Measurement of Thresholds

We have definitely rejected at the present time Fechner's idea of considering a large sensation as the sum of smaller sensations. With the rejection of that concept has also been discarded his generalized law based on that idea. But Fechner's contribution to psychological measurement is not limited to his conception of unit sensations nor to the formulation of the Weber-Fechner Law. His monumental work on the experimental determination of the value of threshold still stands out as a landmark in the progress of our science. These values by themselves are regarded as indirect measures of 'sensitivity' and 'sensible discrimination' of observers. Further, the method and the technique which he conceived, developed and established have been of great value in quantitative psychology. He was the first to introduce the systematic methods of mental measurement and these methods are still being utilized in all quantitative studies of psychology.

Moreover Fechner's work changed completely the outlook of the psychologists. Up to his time psychology was not regarded even as an experimental science. In view of Kant's declaration that psychology could never attain the rank of a true science there were prejudices, doubts, and controversies regarding the adoption of scientific methods in the study of psychology. Fechner's work and his methodology have not only broken the prejudice but have raised psychology, once and for all, to the dignity of a quantitative science. He showed conclusively that the problems of psychology can be subjected to quantitative methods and are amenable to mathematical treatment. Since the publication of Fechner's 'Elemente der Psychophysik' in 1860 there has been a very rapid growth of quantitative work in psychology. In the later part of the nineteenth century innumerable studies on 'threshold values' in all sense departments were made and even to this day we find that interest in this kind of study continues.

Experimental determination of the 'threshold value' is an extremely difficult and complicated task. The value of threshold, as you know, can be best found out by what is known as the Constant Method. It rests on the number of relative frequencies of different judgments obtained by comparing different variable stimuli with a standard stimulus. There are various possible sources of errors which deflect the subject's judgment. Expectation, habituation, practice, fatigue, interest, attention, understanding of the problem, attitude of the subject towards the experiment and external disturbances are some of the chief factors affecting the judgment of observers. These disturbing causes are known as variable factors and their influence varies from time to time as the experiment proceeds. Judgment will vary according to the amount of practice, the degree of understanding of the problem, the interest taken in the experiment and so on.

If observations are made under similar conditions of practice, fatigue, attention, etc. and under similar physical situations, the judgments should be expected to be constant theoretically but, as a matter of fact, it has been found that judgments do vary from observation to observation. This can only mean that in spite of the best efforts of subjects there occur chance deviations in the conditions which influence the judgments. The variations in judgment thus occurring are known as 'chance errors' or 'errors of observation'. The same stimulus in comparison with a given standard may be judged as 'equal' at one time and 'greater' at the next moment. But in a sufficiently large number of observations such variations in judgment are found to occur not at random but to take place in a definable way which can be shown to follow definite mathematical principles. The relative proportions of frequencies of 'greater', 'equal' and 'less' judgments vary as the differences between the standard and the comparison stimuli vary. The variations obey the law of distribution of normal curve.

When the observed data satisfy the law of normal distribution they are called homogeneous. In order to be homogeneous the data must satisfy two conditions: (1) Experiments should be conducted under similar psychophysical conditions, and (2) the number of experiments should be fairly large. Small number of data even when collected under similar conditions of experimentation may not be homogeneous and, again, a large number of data when obtained under asimilar conditions are not necessarily homogeneous. As the homogeneity of data is very rare in psychophysical experiments doubts have been expressed by some investigators[3] regarding the validity of normal distribution of the reports of judgment. In cases of lifted weights and temperature discriminations Culler[4] has shown that about 80% of the whole number of distribution followed the law. The data I have obtained in my psychophysical experiments [5], numbering about 10,000, showed normal distribution. It can be safely asserted that a long series of data when collected under similar psychophysical conditions satisfies the 'Normal' law. When the distribution of judgment does not follow the 'Normal' law it may be inferred that some variable factors are still at work. The data in such cases should not be regarded as reliable.

The data, however, do not mean much till the values of threshold and the amount of chance errors are calculated from them. The values are determined by appropriate applications of refined mathematical formulae. The technique and the process of computing values are very lengthy and laborious. Many shorter methods have been suggested. It is no doubt sensible to use simple formulae for treating a small number of data of doubtful reliability but it is not proper, as Urban [6] has emphasized, 'to treat results of short and long series of experiments in the same way. The energy spent in collecting the vast number of data is wasted if we do not get as much out of these as there is in them'. On the other hand, when the data are not homogeneous and when they are small in number, the application of refined and laborious calculations is a mere wastage of energy.

(v) Discrepancies of Weber's Relation

Weber found in a series of experiments with lifted weights that dR/R was constant for different regions of the intensity scale of the stimuli.

Fechner demonstrated its constancy in many different realms of sensation-intensity. Aubert (1865) and Helmholtz (1866) challenged the validity of Weber's relation on the basis of their own experiments in the field of vision. The ratio was again the subject of investigation by König and Brodhun (1888). They showed that dR/R decreased steadily as the intensity increased up to a certain point beyond which the dR/R increased. Blanchard (1918) corroborated the findings of König and Brodhun. Lowry (1931) has recently re-investigated the way in which dR/R varies at the middle region of the intensity scale. His results tally somewhat with those of König and Brodhun. Detailed experiments of Hecht [7] with light intensities on Mya, a kind of shell-fish, indicate that dR/R for just perceptible response varies with the variation of the values of R.

We find wide discrepancies in the results of different investigators but before we compare their results and draw any conclusion from them it will be pertinent to enquire whether the values were obtained from sufficiently long series of data collected under similar conditions of experiments. First of all, we find from the records of some of the investigators that the data are not sufficiently numerous and, secondly, we notice that experiments were not all conducted under similar sets of experimental conditions. Titchener [8], Fernberger [9] and others thought that in many cases the subjects could not maintain their attitude constant throughout the experiment and they suggested accordingly that the discrepancies were to be explained in terms of the shift of attitude. I think that the inconsistency in the results, that we find in some of the cases mentioned above, may be due to the fact that the results were obtained from defective samples. Moreover, Weber, Fechner, Helmholtz and others varied the 'comparison stimulus' *step by step* by small increments until the subject could notice a change, whereas in some of the above-mentioned experiments the intensity of the stimulus was increased or decreased *continuously* until a change was noticed. This change of condition of the experiment from step by step increase to continuous increase may be responsible for the discrepancies.

I made an extensive series of experiments with lifted weights from 1928 to 1938 under the condition of continuous increase with a view to test the validity of Weber's relation [5]. The results of my investigation were obtained from statistically tested homogeneous data. Some of my findings were found to tally substantially with those of König and Brodhun as well as they were confirmed by results of Hecht, all of whom (as far as I could gather from their reports) used the method of continuous increase in the presentation of their stimuli. The results of König, of Hecht and of myself do not, however, contradict those of Weber, Fechner and others. I do not subscribe to the view that these results disprove the findings of Weber and others as Hecht is inclined to think. The two sets of results were obtained under different conditions. I have shown that the procedure of continuous increase induces in the observers psychophysical conditions (e.g. condition of attitude, condition of attention, condition of expectation and adaptation, etc.) which are radically different from those induced by the procedure of step by step increase. My contention is that the two types of findings express measures of different capacities or of somewhat similar capacities under altogether different sets of psychophysical conditions and as such they are not directly comparable.

(vi) Measurement of abilities

The spirit of the age is that of social service. Influenced no doubt to some extent by the prevailing spirit present-day psychologists have shifted their attention from the study of sensitivity, sensible discrimination and threshold to fields with which human welfare is more directly concerned.

Great progress has been made at the present time in the measurement of 'intelligence', 'abilities', 'personality traits', 'character traits', 'attitudes' and the like. Performances of definite types are graded and indices of the abilities or traits to be measured are calculated. The scores for the various performances are considered to be an indirect numerical measure of the mental processes involved in the performances.

It may be questioned whether such indirect measures can legitimately be regarded as measures of mental processes. In physical sciences indirect measures are not rare. In operations like the weighing by means of a spring balance what is observed directly is the movement of a pointer from the zero mark to another definite scale mark. This scale mark is the indirect measure of the weight. But it has to be borne in mind that the relationship between the amount of movement of the pointer and the mass has been determined at some time or other by some method of direct measurement. So long this is not done the scale cannot be calibrated in terms of any unit. In indirect mental measurements the mental processes involved are not amenable to direct observation of measurement. Hence the scores which are regarded as indices do not actually measure the absolute amount of mental processes involved but they merely indicate the relative positions of the subjects tested in the scale. It is evident, therefore, that the scores of indirect mental measurements show several important points of difference from those of physical measurements. A man whose weight is indicated on the dial of a weighing machine at the 200th mark with the needle is twice as heavy as another in whose case the pointer stands at the 100th mark. But a boy whose score mounts up to 200 in arithmetic performance cannot be said to possess twice as much arithmetical ability as the one whose score stands at 100. Similarly a boy whose I.Q. is 70 cannot be said to possess half as much intelligence as another whose I.Q. is 140.

In physical units there is a starting point of zero mark from which measurements are made, but in psychological determinations it has not been possible to find a similar null point. The zero score in intelligence tests does not mean that the person tested possesses no intelligence; it simply means that the tests applied are not an adequate instrument for measuring such low degree of intelligence as the testee possesses. Furthermore, there are no direct ways of knowing whether the difference in ability as represented by scores 20 and 10 is the same as that represented by 90 and 80. It cannot be said definitely that a boy with an I.Q. of 120 is as far ahead of another with an I.Q. of 100 as the second boy is ahead of a third whose I.Q. is 80. Equal differences of scores give no assurance that there are corresponding equal differences of mental development.

This non-equality of units at different parts of the scale, it must be confessed, is a serious handicap to exact comparison.

Fortunately the attention of many eminent psychologists [10] has been drawn to it and attempts are now being made for the construction of measuring scales with equal units. If such scales can be produced, and there is no reason why they should not be done, they will certainly be more precise than the ones at present in vogue; measurements conducted with them will certainly have higher scientific value than the results obtainable from the use of the existing scales.

The limitations of the measures, however, are not to be considered as obstacles to the progress of psychological measurement. Methods of measurement in physical sciences accepted as models of precision and accuracy before the days of Einstein have now been shown to have definite limitations. Nowadays a unit of time or of space is not regarded as absolutely the same everywhere. In a strong field of gravity space is contracted and time intervals are shortened. The difficulties arising out of inconstancy of units are thus not confined to mental measurements alone. In this respect there is no qualitative difference between measurements in physics and measurements in psychology. Special difficulties in our measurements lie in the problem of selection of test materials to form suitable measuring scales.

To a French psychologist, Alfred Binet, goes the honour of having first devised a scale for the measurement of intellectual ability of school pupils. This device of Binet was of momentous importance for the development of the new science of ability measurement and it has justly been considered as one of the notable contributions in the whole history of psychology. Since the publication of the Binet-scale in 1906 there have appeared many improved and more perfect measuring scales. At present we have numerous devices for measuring intelligence, mechanical ability, musical ability, artistic ability and other inherent abilities.

Certain principles and procedures are followed in the construction of such test scales. They may be outlined as follows: First of all, in preparing scaled tests it is assumed that the ability which the test materials are designed to measure is distributed normally. If a large number of individuals are tested, the frequency distribution of scores will follow the normal curve. The test materials which do not give measures that satisfy this condition of normal distribution are not regarded as adequate test instruments.

But it may be mentioned here that there are some practical difficulties connected with the fulfilment of this condition. The experimental data are never exact, so they never exactly fit a normal curve. It remains to be determined statistically how closely the normal curve gives 'fit' to the observed data and how much divergence from perfect normality should be allowed.

Another difficulty, though of a theoretical nature, deserves to be stated here. The assumption that the ability concerned is distributed normally can never be proved in a logical manner, because that would imply the previous existence of the scale, whereas the scale itself is formed on that assumption. There is, however, ample justification for believing in a normal distribution. Most of the biological measurements that we are acquainted with are found to be normally distributed and hence it would not be a violent departure if we assume a normal distribution in mental traits too.

Secondly, in the construction of the scales it is assumed further that the ability which the scale is designed to measure is native. The materials are so chosen that the effects of difference due to training and experience may be reduced to the minimum.

But this condition, too, can rarely be satisfied in the construction of the scale. Test scales primarily deal with common materials with which children are more or less familiar. Hence they show better performance results with materials with which they are familiar than with less known things. The influence of familiarity may to a great extent be minimized by taking a large number of test items involving all sorts of material. For the convenience of administration of the test the number of items has, however, to be kept limited. The influence of experience and education therefore cannot be altogether eliminated. As a consequence it cannot be said without qualification that the scores which we secure by means of these tests are measures of unadulterated native ability.

Thirdly, the items of the scale are so selected that they give consistent results. If the members of a group are tested a second time under similar conditions and if each individual makes a score which differs very little from his first performance, the test is said to be reliable. More accurately speaking, the test can be said to be trustworthy if the two sets of scores correlate highly with one another. The coefficient of correlation can thus be used as a measure of reliability of test materials. If the coefficient of correlation of test materials is found unsatisfactory and if we are definite that the two scores have been obtained under similar conditions, the suspicion would be that the choice of the test materials has been defective. It is possible to remedy to a certain extent such defects of test material through proper selection, elimination and arrangement as also by increasing the number of the items. But by no means can the coefficient of correlation be found to be a perfect one. Besides the fallible material, a potent factor of error is that it is never possible to maintain the conditions of experiments and the psychophysical state of the testee constant on the two occasions of examination. It hardly needs be reiterated that the subject's score of performance depends on his interest, effect, emotional condition. past experience, rapport with experimenter and external distraction. However hard one may try to maintain the similarity of these conditions, they are bound to fluctuate. Different individuals will be affected differently by the varying conditions and, as a result, the correspondence between the two scores will never be exact. The question then is: How high the coefficient of reliability should be, in order that the test may be regarded as satisfactory? Authorities seem to have no definite view on this point. Some regard ·80, while others consider ·60 as the satisfactory criterion of reliability.

Lastly, psychologists are faced with a very important problem, viz. that of the validity of test materials. A test scale is said to be valid when it actually measures what it intends to measure. The intelligence tests claim to measure intelligence. But is there any guarantee that they really do so? It has been said that most of the tests measure an 'unanalyzed hotch-potch of abilities'. Terman and others selected those tests which correlate highly with other independent outside measure. Teachers' estimate of the ability of the children under their charge has been used as such an outside measure, but it is obviously very imperfect. Psychologists are still unable to agree as to what they mean by 'intelligence'. It is very unlikely that the teachers' view will be more concordant. Spearman [11] has developed a more scientific method in determining the validity of test materials. According to him an individual's success in a test is determined by two factors, one being general intelligence '*g*' which operates in the performance of all tests and the other being a specific factor '*s*' which accounts for partial success in a given test. The relative weight or importance of '*g*' and '*s*' varies considerably from one test to another. An individual's score thus depends on the extent to which he possesses the two factors and on the importance of each of the two factors in the given test.

Spearman provided a mathematical device whereby the relative influence of the two factors could be quantitatively calculated. By applying his mathematical process it is possible to select test items which are saturated with '*g*' and to isolate those saturated with '*s*'. The idea is that tests which are saturated with '*g*' are valid measures of general intelligence and tests saturated with '*s*' are measures of specific ability. It is no longer necessary to depend on the old-fashioned method of correlating test scores with fallible outside measures to examine the validity of tests.

The test scales have been formed and standardized on these principles, but the scales thus formed are still far from being perfect and being suitable for universal application. When a test scale is standardized by examining, say, a representative group of literate Bengali children it would be an adequate instrument to measure the ability concerned of such children whose habitat, socio-economical position, general level of training and education are the same as those of the group tested for standardization. The scale will not be applicable to children of other nationalities living under different conditions. We should never forget this limitation of the test scales, otherwise we shall be liable to commit serious errors particularly in making efforts at comparisons.

There are many variable factors which influence a subject's score on a given test. On applying the same or similar tests on different occasions within an interval of a month or so the test scores of individuals have been found to vary by amounts greater than the limits of variations set by the coefficient of reliability of the test. It is considered that such variations are due to change of subjects' interest and effort and also to change of emotional conditions, there being no question of any change of innate ability within so short a time.

A scale is imperfect in the sense that it does not indicate how much of the score of an individual is due to his innate ability and how much of it to other factors. For example, a subject's low score, say 80, which has been obtained with an adequate standardized test scale cannot assess how much of it is due to his lack of innate ability, how much to absence of effort and interest on his part and how much to the inhibitory effect of emotional conditions. It is necessary, therefore, to take particular care in interpreting test scores and differences in test measures. Rearing a child in a better environment may yield higher score but before we make any conclusion regarding his innate ability it must be ascertained whether the difference is statistically significant and in case it is found to be so we should try to determine how much of the difference has to be attributed to better familiarity with the test materials, greater incentive and healthier emotional condition.

I am not in any way minimizing the overwhelming importance of the measurement of abilities. I simply desire to emphasize that mental test scores should never be accepted in the same way as the physical measurements are trusted. Certainly the best test scale measures the ability concerned but it does that within certain limits. We must be familiar with the underlying principles of the construction of the scales as also with the limitations of the test scores before we proceed to interpret and assess them.

(vii) Measurements of aesthetics and attitudes

In the construction of the scales described above, the performances are scored quantitatively. There are many achievements, e.g. drawing, composition, aesthetic appreciation of colour, etc., which cannot be measured in terms of any constant unit. Achievement in such cases is always measured by comparing an individual production with a scale consisting of 'standard productions' of varying character whose values have been determined beforehand. These scales are known as 'Product Scales'. These are constructed on the principle that 'equally often noticed differences in equality' are equal. If a composition '*A*' is rated better than a composition '*B*' by 60% of a group of competent judges, and a composition '*X*' is estimated better than another '*Y*' by 60% of the same judges then the difference between *A* and *B* is considered to be equal to that between *X* and *Y*. On this basic principle scales of handwriting, composition and drawing have been prepared.

Thurstone [12] and others, however, have questioned the validity of the assumption of the equality of the equally noticed differences and have propounded different methods for the construction of such scales. Taking an entirely original approach to psychophysical measurements, Thurstone [13] developed a new system in which the categories of judgments in comparing sense-intensities, those in comparing drawings, aesthetics, and affective values of colour, etc., as well as those in giving opinions regarding war, religion and the like, are brought under one general principle. Thurstone states that in comparing sense-intensities the greater the difference between the two intensities the less is the chance of giving equal judgments. The Gaussian function is obeyed in returning judgments. In gauging drawings, etc. the greater the disparity between the two specimens the less is the probability of judging them as same. Here also the distribution of judgment satisfies the psychometric function. Similarly, he states that in giving opinions, say with respect to war, if a man hold a particular opinion '*A*', the probability that he will endorse another opinion '*B*' depends upon the separateness of '*A*' and '*B*'. The greater the separation the less is the probability of his endorsing the two opinions. It is also a Gaussian function. On the basis of this general principle Thurstone has developed mathematical formulae by means of which values of sense-distances, relative excellence of handwriting, drawing, composition, beauty and aesthetics, relative values of disparities of opinion and the like can be determined.

Thurstone [14] has opened a new field of research in quantitative psychology. Problems that could not be attacked before in a quantitative way now yield to measurement. Workers, especially those who are interested in aesthetics and in the problems of social psychology, have not been slow to take note of Thurstone's methods. It should be mentioned, however, that opinions at present vary, as they will naturally do, in the pioneer stage of any movement concerning the value of both the psychological assumptions [15] and the mathematical principles [16] underlying Thurstone's hypothesis. Inadequacies of the first stage are sure to be removed by further work on this line when new insight gained will bring about refinements of procedure.

(viii) Measurement of individual differences

In recent years great emphasis is being laid on the measurement of individual differences. The development of the technique of factor-analysis is responsible for this spirit. According to the factorist any test performance of an individual is the resultant of many casual factors. These causal factors are isolable. They are the joint determinants of the individuals' performance.

About thirty-five years ago, Spearman found that the various tests of abilities showed more or less close correlations and further he noticed that these correlations tend to form an orderly system or hierarchy. This fact led him to formulate his now deservedly famous two-factor theory. According to this theory when a table of intercorrelations between the scores of individuals on different tests exhibits the hierarchical relation, an individual's performance upon a test can best be explained in terms of two factors—one general '*g*', another specific '*s*'—peculiar for each test.

Since the publication of Spearman's theory many intercorrelations of different tests have been determined. But it has been found that in many cases the hierarchy (better known as tetrad equation) is not satisfied. Tryon [17] has demonstrated that in no case, out of the ten studies made by him, the tetrad criterion was really satisfied by the original data. As a result of such criticism Spearman was forced to admit the presence of 'group factor' which is common to a group of tests. For example, all verbal intelligence tests together with other tests depending on manipulation of language, involve a 'verbal factor' besides '*g*' and specific factors. In the same way all tests of performance contain a 'practical factor' in addition to the '*g*' and specific factors.

The interpretation of hierarchy, on the basis of one single general factor and another specific independent factor, has been contested by Thomson [18] who advances a 'sampling theory' which accounts for the hierarchical relations in a better way by assuming the existence of numerous factors which combine in various ways and numbers.

This superior explanation of the hierarchy in terms of numerous factors as well as Tryon's criticisms have given a severe blow to Spearman's theory. Most of the psychologists at the present time tend to support the view that multiple factors rather than two contribute to ability. But the real interest in the quantitative study of the multiple factor-analysis was not taken until Kelley's [19] works were published in 1928. In 1931 Thurstone [20] suggested a mathematical technique for obtaining principal independent factors that are operative in producing a given correlational coefficient of tests as also for calculating the respective influences of these factors on the coefficients.

Thurstone's method of analysis has been found to be very laborious. Hotelling [21] has developed a neat technique by which it is possible to resolve with more ease a wide variety of tests into a set of independent uncorrelated factors, as also to assign scores for each of the factors isolated to each of the individual subjects tested.

Factorists claim that by means of such analysis they will be able to isolate all possible fundamental factors that are operative in different performances and to obtain individual scores on each of these independent factors. They claim further that it would be possible to represent an individual as a point in a multi-dimensional factor space, each dimension representing a factor. The position of the individual would be unique, for no other individual possesses exactly the same combination in the amounts of various factors. Clearly an enormous amount of research work will be needed before the whole realm of human abilities be resolved into factors. Difficulties are stupendous but let us hope that all those will be overcome.

(ix) Present position

Theoretical objections raised against the measurement of psychological magnitudes have been partly met; difficulties of mental measurement have been to a large extent overcome. The importance of the measurement of mental traits has been fully realized. Mental scales of abilities are now regarded as the best tool so far discovered for the prediction of the testee's future educational achievement as well as his vocational success. Relative values of attitudes, opinions, feeling, aesthetics, etc. can be somewhat correctly determined by special devices like Thurstone's scales and methodology. On the other hand, it has been clearly apprehended that mental scales are not as perfect and universal as the physical scales are conceived to be. No mental trait can be measured directly by lying a scale alongside it. It requires a high degree of skill and labour on the part of the experimenter to assess the ability and to interpret the measures properly. There has been a tremendous improvement in the methods of mental measurement and in the technique for proper interpretation of measures within the last twenty years, but still much research is needed before the measurement of psychological magnitudes can approach the reliability and universality of that of physical magnitudes.

(x) Conclusions

Since the pioneer work of Binet a considerable number of studies of mental measurement has been enthusiastically undertaken in various countries, especially in America and Great Britain. In this country not much work in this field has been carried out though, as Bose [22] has said that, 'a fair amount of first-rate work has been done' on problems other than mental measurement. The paucity of work is not due to want of enthusiasts. The glamour of intelligence tests has caught the 'imagination of many and the output of work has been voluminous'. But I hope that you will not mind my saying that none of these works have been carried as yet to the final stage of perfection. It is one thing to devise test items similar to already published foreign tests but quite another to standardize them to suit local conditions. No mental test is perfect unless it is properly standardized. The process of standardization involves a large collection of data and statistical work. Most of us fight shy of statistics and statistical formulae. This timidness, I am inclined to think, is greatly responsible for the slow progress of mental measurement in our country. I do not know what the state of affairs is in other provinces but my twenty years' experience in the University of Calcutta has shown that even among the best students interest in the subject of psychology is generally accompanied with a dislike—sometimes an intense one—of mathematics. This fact itself may be considered as a psychological problem which for the present I leave to the psychoanalysts to solve.

The shyness for mathematics is certainly unnecessary, for it is not very difficult for a seriously minded person to understand the principles of statistical formulae and to apply them properly. Sound knowledge of the principles of the normal probability curve, of the methods of correlations and of some working knowledge of the technique of factor-analysis are no doubt essential prerequisites to mental measurements, but I consider that such knowledge can be acquired without much difficulty within a reasonable time, provided one strives for it earnestly. Training in higher mathematics is not indispensable for acquirement of such knowledge. Even if one fail to master completely the statistical principles his work need not suffer on that account. The Indian Statistical Laboratory at the Presidency College, Calcutta, is ever ready to help the workers in any field of statistical investigation.

A serious drawback, however, should be pointed out and I specially desire to draw the attention of all concerned to it. There is almost a complete absence of co-ordination of the work that is being conducted on mental testing here. The process of standardization of a test is lengthy and laborious. It requires a huge amount of labour both in collecting data and in evaluating the results. It can very seldom be adequately performed by a single individual. What we actually find, however, is just this lamentable fact of individual workers hastily devising tests and rushing to standardize them. Nothing but failure can be the result of such procedure. I should like to suggest in bringing my address to a close that instead of vying with one another in taking credit for first devising and standardizing a test, psychologists of each province should work together to construct scales of tests and to standardize them properly. Non-co-operation may be successful in other fields but intimate co-operation with other workers, frequent discussions about the technique, methods and results are the *sine qua non* of progress in scientific investigations especially in the field of mental measurement. Now that the value of testing has been justly realized, its utility in vocational selection and guidance has been properly recognized, its fruitfulness in educational and various other fields has been adequately appreciated, well-planned intensive co-ordinated work is all that is necessary to carry our mental testing programme to the desired level. If all of us who believe in mental testing put our intellectual and material resources together, I am sure we shall be able very soon to reach our coveted goal. For each province then we shall have thoroughly reliable, valid and recognized tests of intelligence, of temperament, of vocational fitness and of various other abilities and aptitudes. The results we shall obtain are bound to be utilized to their advantage by different educational, vocational and industrial organizations of the society. May that day come soon is my earnest prayer.

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SECTION OF ENGINEERING

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Presidential Address

(Delivered on Jan. 3, 1942)

EDUCATION FOR THE ENGINEERING INDUSTRY

INTRODUCTION

Education in India generally has often been criticised as being too academic in method as well as content and divorced from the actual needs of the country. Higher education in particular has been exposed to criticisms of this nature by various educationists and others interested in educational problems. The remedy appears to lie in encouraging the growth of a vocational bias in the earlier stages of the educational process and the development of a properly co-ordinated system of technical education in the secondary and higher stages. Such a development would not only relieve the overcrowding and consequent unemployment, so common in the 'liberal professions', but correct the existing disparity between the provision for technical and non-technical education. As Lord Eustace Percy, a former President of the British Board of Education, said, 'It is the most serious problem that confronts this country in common with the whole industrial world at the present moment. The brutal truth is that while, as Pascal said, a man's choice of his trade is the most important thing in his life, this crucial choice is about the one thing for which our public system of education has made hardly any attempt to prepare its pupils'. He was, of course, referring to Great Britain in 1933. How true these words are for India to-day !

The distinction formerly made between the educational value of classical and technical instruction is fortunately disappearing but there may still be some who may be inclined to put classical education on a higher plane than technical education. To quote Lord Eustace Percy again [1]: 'The true function of education is a creative one—to create new forms of skill and by so doing to confer a higher social status upon occupations

[1] Page 61, Education at the Cross Roads, by Lord Eustace Percy, 1930.

which do not at present possess it, or, as is the case in some crafts, have lost or are tending to lose it. By fulfilling that function education can, at one and the same time, enlarge human capacities and change the whole texture of human society. Educational reformers have too often contented themselves in the past with what is really a servile view of education, making our schools the slaves of existing social standards instead of the creators of new ones, and demanding exclusively a development of those parts of our educational system which can admit men to the coveted social status at present belonging to the professions and the middle and higher walks of commerce. It is in the technical colleges that we shall find the opportunity for a more real and a more fundamental reform'.

Public interest in technical education has lately been aroused as it is being gradually realized that the industrialization of the country cannot be carried out by men trained in pure science only. The technician serves as a link between science and industry and if efficient and stable industries are to be built up it is necessary to ensure that a steady supply of technically trained persons is available to all branches of industry.

It is hardly necessary at this stage of our national development to stress the necessity of building up the industries of India, notwithstanding the difficulties inherent in a period of world war. Scientists, businessmen, politicians and others have repeatedly spoken about this urgent need and the Government of India have accepted it as their policy to encourage the growth and development of Indian industry not only now but also after normal peace conditions are restored. The establishment of the Board of Scientific and Industrial Research and the Industrial Research Utilization Committee can be accepted as an evidence of this. In a recent broadcast Sir Alexander Roger is reported to have said, 'Industrialize your country and the key of the future is in your hands'.

It is also generally accepted that the economic structure of India will remain unstable and unsound so long as industries are not developed to provide a balance to agriculture on which it has been based so long. Various steps of a scientific, economic and political nature are being taken to foster the growth of industries and it is the aim of this address to focus attention on one of the most vital aspects of industrial development, namely, the training of skilled personnel to run the industries. Without trained hands and trained minds no country can hope to develop and maintain industries in this highly competitive age.

History of Technical Education in India

It is not proposed here to deal in detail with the history of technical education in India but merely to indicate the salient points which would help in understanding the complex problems we are now facing. The early stages of organized technical education in India were closely associated with the needs of the Public Works and other Departments of Government and the 'big four' engineering colleges of India, namely, Roorkee, Poona, Guindy and Sibpur, were established during the middle of the nineteenth century mainly to meet these needs. It must be mentioned here that as in other countries there existed in India a system of craft apprenticeship from early times. The introduction of machinery on a large scale, however, changed the character of industrial skill and a smaller proportion of workmen needed purely manual skill, while a large proportion required a knowledge of general principles, which could more satisfactorily be learnt in a technical school than acquired by practice.

[1] The establishment of a chair of engineering in connection with the Hindu College in Calcutta was sanctioned in 1844-45 (*vide* Annual Report of the Council of Education for 1844-45). A salary of Rs.300 per mensem was guaranteed to the Professor of Civil Engineering and half the fees of pupils attending the course, the remaining half to be devoted to the purchase of books, apparatus and such means of instruction as might be necessary. The chair of engineering, however, remained vacant as no professor was available. In July, 1847, the Council of Education was asked by Government to report on two schemes, one formulated by the Bombay Government and the other by the Military Board. After considering the report of the Council, Lord Dalhousie recorded a minute recommending to the Court of Directors of the East India Company the establishment of an engineer class at each of the Presidencies. The Calcutta College of Civil Engineering was thus opened in November, 1856, at Writers' Buildings for the purpose of supplying properly qualified candidates for all grades of Public Works and Survey Departments and for employment under different companies engaged upon Railways in India. It was affiliated to the Calcutta University in 1857. The college was amalgamated with the Presidency College, Calcutta, in 1865 and was named 'The Presidency College, Civil Engineering Department'. On the 5th April, 1880, it was transferred to Sibpur under the name of 'The Government Engineering College, Howrah'. A Mining Department was opened in February, 1906, to train managers and assistants for the large number of mines in India. This was subsequently transferred to Dhanbad to form the nucleus of the Indian School of Mines in 1926. At present there are degree courses in Civil, Mechanical and Electrical Engineering and Metallurgy in operation.

[1] The details given here regarding the four engineering colleges have been collected mainly from the 'Selections from Educational Records, part II, 1840–59, Bureau of Education, India' published in 1922.

A Civil Engineering College was started at Guindy in 1858 and the Director of Public Instruction, Madras, in his report for 1858-59 made the following remarks about it: 'The long projected Civil Engineering College has been brought into operation during the year under review; the Survey School, formerly attached to the Board of Revenue and subsequently to the Chief Engineer's Office, having been adopted as its basis. The plan upon which it was originally proposed to establish it, viz. that it should provide instruction for all grades of the Public Works Department, except officers of the Corps of Engineers and Civil Engineers educated in England, has been abandoned for the present on financial grounds; and it has been determined to confine it to training candidates for the grades of sub-overseers and of assistant engineers'. At present there are degree courses in Civil, Mechanical and Electrical Engineering.

As early as 1824 an Engineering Institution was in existence in Bombay but its subsequent history is obscure. A class for training engineers was opened in the Elphinstone Institution in 1844, but for want of suitable candidates for admission the class was broken up at the end of the year 1847. The Poona Engineering Class and Mechanical School was opened in July, 1854, its aim being to provide suitable instruction for subordinate officers in the Public Works Department. In July, 1863, Sir Cowasji Jehangir Readymoney presented the sum of Rs.50,000 to Government and a college was established which was affiliated to the University of Bombay in 1866. At present there are degree courses in Civil, Mechanical and Electrical Engineering in operation.

The early history of engineering education in the North-Western Provinces is intimately connected with that of the Thomason Engineering College, Roorkee. This institution was a direct product of irrigation and other engineering schemes undertaken by Government. In 1847 the vigorous prosecution of the Ganges Canal was determined upon and at Roorkee large workshops, etc. were constructed. The Lieutenant-Governor, Mr. Thomason, perceiving the appropriateness of the time and place, proposed the establishment of a college to supply a staff of engineers. The scheme was sanctioned and in 1849 the institution was placed on a permanent footing. The main buildings were, however, completed in 1856. There is at present a course for civil engineers of the degree standard in operation.

It will thus be seen that systematic instruction in Civil Engineering has been available in India for nearly a century and the standard so far attained can be considered as fairly satisfactory. Many new institutions have since come into existence which provide courses in Civil Engineering subjects but the remarkable feature of this development is the insufficiency or lack of instruction in other important engineering and technical subjects almost up to the end of the nineteenth century. Mechanical and Electrical Engineering classes were started in a small way at each of the 'big four' engineering colleges towards the end of the nineteenth century which have developed into degree courses during the last few years.

In May, 1853, Sir Jamsetjee Jeejeebhoy offered on certain terms to appropriate a sum of Rs.1,00,000 to a school for the improvement of Arts and Manufactures in Bombay. The institution was opened in 1856 and a section for Architecture was added in 1880. This is probably the only centre for advanced architectural instruction in India to-day. The Victoria Jubilee Technical Institute was started in Bombay in 1888 with Textile and Mechanical Engineering departments. A department of Metal Working and Enamelling was started in 1898 and a department of Electrical Engineering was started in 1903. The department of Technical Chemistry came into existence in 1906. At present there is also a department of Sanitary Engineering and Plumbing.

The College of Engineering and Technology at Jadavpur was founded in 1906 by the Society for the Promotion of Education in Bengal, with the object of training students for the industrial pursuits as well as to develop and utilize the material resources of the country. The college now offers courses in Mechanical, Electrical and Chemical Engineering.

The Indian Institute of Science owes its origin to the munificence of the late Mr. Jamsetjee Nusserwanjee Tata, who in the year 1896 proposed to vest in trustees properties to the capital value of thirty lakhs of rupees for the purpose of endowing a research institute for India. The late Mr. J. N. Tata desired to build and endow an institution which should provide Indian students with such facilities for work and training as would enable them to compete on equal terms with other countries as a producer of new knowledge and to aid Indian students to serve India in science and technology. The first batch of students were admitted to the departments of General Chemistry, Applied Chemistry and Electrical Technology in July, 1911, the department of Organic Chemistry was opened in September of the same year. The department of Physics was opened in 1933. The all-India character of the Institute is always kept in mind and attempts are made to get the best students from all parts of India.

The Engineering College of the Benares Hindu University was started in 1919. The college provides a combined course in Mechanical and Electrical Engineering for the degree of B.Sc. (Engineering). The University also has departments of Mining and Metallurgy and Glass Technology.

In addition to the institutions referred to above there are at present numerous other technical institutions in India of the secondary and advanced type doing good work and if they are not mentioned here it is only because of the very limited space available in a paper of this kind. The fact remains, however, that we have failed in providing suitable and sufficient training not only for newly developing industries but also for industries which have been in existence for many years. This shortcoming is noticeable more at the secondary stage of our educational system than at the higher stages.

The first comprehensive attempt to review the subject on an all-India basis can be said to have been made by the Indian Industrial Commission whose report was published in 1918. Their remarks about technical education in India as it existed before the last war may be summarized as follows:

'In their resolution of the 18th June, 1888, on the subject of technical education, the Government of India pointed out that the education hitherto provided had been too exclusively literary in its bent; that industrial training was required in view of the necessity of securing a greater variety of occupations; and that technical education could be provided with advantage at once for industries which had already reached a comparatively advanced stage of development, such as the textile and engineering industries, though the danger of establishing a system of training for those insufficiently advanced was noted. The necessity of giving a more practical bias to general education was emphasized, and Local Governments were incited to take action in these directions.

At the beginning of the present century it was realized that measures taken in the Education Department during the previous fifteen years had been totally inadequate to meet the needs of India and the growing recognition of the necessity for a greater diversity of occupations, to absorb the energies of the ever-increasing numbers of the educated classes. Lord Curzon accordingly summoned in Simla in 1901 an Education Conference which reviewed the situation and recommended drastic reforms in the methods of higher education, with a view to render them more effective and practical.

Almost immediately after the Conference, the Government of India appointed a Commission to report upon industrial education; but the report of the Commission was never published.

The experience of the war (1914–1918) itself has been responsible for a new attitude on the part both of Government and of leading industrialists. They realize that it is necessary to create in India the manufactures that are indispensable for industrial self-sufficiency and for national defence, and that it is no longer possible to rely on free importation of essential articles in time of war.

It will be necessary in the immediate future for Government to consider the more general question of the part to be played by the existing engineering colleges and the Universities in providing for the increasing need in India for scientific, technical and technological training. The simplest way of meeting this demand would be to expand the engineering colleges into technological institutes by the creation of new departments.

Up to this point our recommendations regarding industrial and technical education are such as should be carried out by Provincial Governments; but, we think, it will be necessary ultimately, if not in the immediate future, to provide India with educational institutions of a more advanced character, which no single province could support or fill with students, yet which each province will need to a greater or less extent. As soon as our foregoing recommendations have had time to develop their full effect, it would be advisable to proceed further and establish imperial colleges of the very highest grade.'

The Calcutta University Commission under the Chairmanship of Sir M. Sadler also enquired into the subject of technical education in 1917–19 and came to similar conclusions. But when the stresses and strains of the last war were relieved, however, most of these recommendations were unfortunately forgotten. Departments of Industries were started in all provinces but little or no additional provision was made to develop technical education on an all-India basis.

In 1936, the Government of India invited Messrs. A. Abbot, formerly H.M. Chief Inspector of Technical Schools, and S. H. Wood, Director of Intelligence, Board of Education, England, 'to advise on certain problems of educational reorganization, and particularly on problems of vocational education'. They prepared a report on 'Vocational Education in India' which was published by the Government of India in the following year. Some of their observations may be quoted here as they throw light on conditions at present obtaining in India:

'Vocational education is not on a lower plane than literary education, since the full purpose of education is to develop the whole powers of the mind, body and spirit so that they may be devoted to the welfare of the society.

No country can develop its trade and industry through the work of second-rate men only. The conditions in India, as in other industrial countries, demand that business shall have its fair share of the best brains available in the country.

General and vocational education are not essentially different branches, but the earlier and later phases of a continuous process. Each subject in the vocational school has its origin in the non-vocational school.

General and vocational education should not, however, be provided in the same school, since the pupils in the two types have very diverse aims. Education for industry can, with certain safeguards, be given in the same school as education for commerce.

Vocational education is not a matter for the school alone, since it is a specific, and not a general, preparation for employment. Industry and commerce must co-operate with educational organizations if the vocational education provided is to be appropriate, and adequate organized co-operation of this kind does not yet exist in India.

There appears to be a common belief in India that a more adequate supply of vocational education would lead quickly to greater use being made by organized industry of the raw materials of the country. The existence of skilled workers, though essential, is not in itself enough to create organized industries. Capital, means of transport and reasonably assured markets are also needed. Although a certain degree of caution in the plans for training men for organized industry is therefore necessary, schemes for improving the skill and efficiency of cultivators and small-scale workers can be safely undertaken.'

As a result of Messrs. Abbott and Wood's report, a few experimental technical schools have just been started in Bombay and Hyderabad and a Polytechnic has been opened at Delhi early in 1941 with Mr. W. W. Wood as its first Principal.

Recently, through the unusually large demands made by Government for technicians for war work, the subject of technical education has again assumed importance. The Central Government appointed a Technical Training Enquiry Committee in 1940 under the chairmanship of Mr. John Sargent, Educational Commissioner with the Government of India and Joint Secretary of the Department of Education, Health and Lands, and it will be of interest to quote some relevant passages from their report:

'The object of the enquiry is not to review technical education generally.

While our primary duty is to suggest how the demand for additional skilled workers for war purposes may be met, we are not unmindful of the wider implications of our terms of reference or of the possible effect of our recommendations, if implemented, on the development of post-war industry in India.

It remains for us to assess the prospect of post-war industry being able not only to retain the additional workers taken on for war work but also to absorb the skilled personnel no longer required for the Defence Services. If we may leave out of account the possibility of fundamental changes as the outcome of the war both in national relations and the structure of society, the problem appears to present two main aspects, the industrial and the educational.

From the educational aspect, although we have had neither the time nor the opportunity to formulate first-hand criticisms on the present system of technical instruction in this country, we are advised on good authority that while it by no means deserves the wholesale condemnation it sometimes receives, it may not unfairly be described as too academic in content and too far divorced from first-hand contact with the needs and conditions obtaining in industry.

Turning to the post-war problem we are impressed by the fact that in the technical colleges and institutions, about which we have some information, there are several thousand students taking degree courses or courses of equivalent standard. Although degree students from some institutions are successful in attaining in a reasonable period to posts of responsibility in industry, the position in the country generally is not satisfactory. The time at our disposal has been too short to allow us to analyze the causes of this, though we believe them to lie mainly in the defects of the present system of technical education to which we have already called attention.'

The latest development to be noticed in the history of technical education in India is the formation of an Association of Principals of Technical Institutions (India) on the 28th July, 1941, with the object of co-ordinating the efforts of different bodies interested in this subject. The formation of such an Association can be considered as very opportune, as it must have been evident from what has been stated above that though much has been written on this important subject very little achievement, on the whole, is in evidence. The Association will foster all-round co-operation between educational interests, industry and professional bodies (such as the Institution of Engineers, India) and prepare a systematic plan for future development. The Association has already realized that 'it is essential to have some method of co-ordinating the efforts of Central and Provincial Governments and other private bodies, as it would not be possible for any one agency to cater for the national requirements in an economical and efficient manner. New industries are springing up everywhere and old ones are going forward under rapidly changing conditions. In order that this process may continue with ease and efficiency, it is desirable to evolve a system of technical education which can cope with the ever-changing requirements of industry. In many of the provinces great changes are either proposed or are already taking place in the system of secondary education. Technical or vocational education should also find its due place in this large field.'

Primary and Secondary Education, and evening and part-time day classes

Before we proceed to consider this subject with special reference to conditions in India it may be of interest to quote the present trend of thought in Great Britain as expressed in the 'Report on Secondary Education with special reference to

Grammar Schools and Technical High Schools' published by the British Board of Education in 1939.

'Much of the fear of "Vocationalism" and of early "Specialization" in secondary schools has arisen through misunderstanding and failure to define these terms and to face the facts of all educational development. It is not always realized how much truth there is in the view expressed in a memorandum submitted to us by a distinguished American educational administrator, Dr. John L. Tildsley of the New York Board of Education. "There is no subject," he wrote, "in the curriculum of any type of vocational school for any age of boy or girl that might not be liberalized while at the same time furnishing the highest degree of vocational effectiveness." Certainly, in any subject worthy of inclusion in a school curriculum it should be possible to lead the pupil to look beyond the immediate processes in which he is engaged to a wider human and social background. A subject which requires the extreme accuracy of working necessitated by many forms of workshop training can scarcely fail to provide a real moral and intellectual discipline. The dominant position in liberal education held so long by the study of Greek and Latin was largely based on the claim that that study combined a similar insistence on accuracy with an understanding of the place of classical literature in human life and history. Any subject which is so taught as to perform this dual function, demanding a high standard of accomplishment and at the same time awakening in the learner a sense of its wider meaning, serves in a sense the same end, whether in conventional terminology it is called academic or technical, liberal or vocational. Its effect is the same, "the unfolding", to quote Dr. Tildsley again, "of all the powers in the man, the making of them usable to the utmost degree in the special phase of production or the special phase of living in which he may chance to engage".'

A similar point of view, though with greater emphasis on the trade or vocation as a suitable educational medium, has been expressed in India under the popular name of the 'Wardha Scheme'.[1] The principle of intellectual training in and through a craft is the most fundamental feature of the scheme. It is based on the following proposition of Kropotkin:

'In the interests of both science and industry, as well as of society as a whole, every human being, without distinction of birth, ought to receive such an education as will enable him or her to combine a thorough knowledge of science with a thorough knowledge of handicraft.'

This proposition has been enlarged upon and explained by Mahatma Gandhi in the following words:

[1] The Wardha Scheme of Education by C. J. Varkey, published by the Oxford University Press, 1940.

(1) 'Every handicraft has to be taught not merely mechanically as is done to-day, but scientifically, i.e. the child should know the why and the wherefore of every process.'

(2) 'The core of my suggestion is that handicrafts are to be taught, not merely for productive work, but for developing the intellect of the pupils.'

(3) 'A vocation or vocations are the best medium for the all-round development of a boy or a girl, and therefore all syllabuses should be woven round vocational training.'

There has been considerable public discussion on these and other features of the scheme, but it can be said that the modern trend of educational thought is generally in agreement with the first two points mentioned above and the scheme can, therefore, be considered as a valuable contribution to the solution of our problems. At its meeting held in January, 1938, the Central Advisory Board of Education of the Government of India appointed a committee to examine the scheme 'in the light of the Abbott-Wood Report on "General and Vocational Education" and of other relevant documents'. The following are some of the recommendations of the committee which have met with the general approval of the Central Advisory Board of Education :

(1) The age-range for compulsion should be 6 to 14 years, but children can be admitted to the Basic School at the age of 5.

(2) Diversion of students from the Basic School to other kinds of schools should be allowed after the age of 11 plus.

(3) The Wardha Scheme of basic education is in full agreement with the recommendations made in the Abbott-Wood Report so far as the principle of learning by doing is concerned.

(4) Certain elements of cultural subjects cannot be correlated with the basic craft, and must be taught independently.

A compulsory course of eight years is proposed under this scheme with a view to combine what is now called primary education and secondary or high school education up to the Matriculation Standard. It will be seen therefore, that the new interest now being manifested in vocational education indicates a radical change of outlook which can only become effective if it succeeds in overhauling the primary and secondary stages of our educational system.

The present tendency in Great Britain is to emphasize the complementary nature of the relationship between general and vocational education which are considered as parts of a single process. Under the British Education Acts it is the duty of the parent to cause his child to receive efficient elementary instruction in Reading, Writing and Arithmetic, from the age of 5 until the age of 14 years.[1] It is now the definite policy of the British Board of Education to make a clear distinction between primary education up to 11 years of age and post-primary education after that age. The result of that policy is to create self-contained primary schools for children up to 11 years of age. In England a secondary school is a school which provides a full-time education of a general, as distinct from a vocational, character for children from about 11 years of age to about 17 years or more. There is, however, a wide variety of instruction, apart from that obtained by attendance at a University, available for boys and girls on leaving the elementary or secondary school, and at later stages. Broadly speaking, vocational courses, i.e. instruction definitely related to employment, may be either full-time instruction in preparation for employment upon which the student has not yet entered, or part-time instruction which the student attends after entry into employment.

In Great Britain the Spens Committee[2] recommend that the name, Technical School, be used as a general term to describe all schools which recruit at the age of 13+ and provide a course of two or three years' duration. They further recommend that schools having an age of recruitment of 11+ and providing a five-year course shall be known as Technical High Schools. They state 'we fully realize that in selecting children at the age of 11+ the wishes of the parents, assisted by the advice of the heads of the contributory schools, should always have a predominant weight in determining the choice of school for children of that age. But there should be another age-point, namely 13+, in all schools at which transfers should, if desirable, be made from one type of school to another both with the object of eliminating any misfits which may have occurred and with the purpose of encouraging any special aptitudes which may have developed in children between the ages of 11+ and 13+, and furthermore, of allowing a change of choice on the part of the parents. The establishment of a more or less common curriculum for pupils between the ages of 11+ and 13+ in all types of secondary schools would render it comparatively easy to effect mutual transfers at the age of 13'.

They further recommend the establishment of 'a new type of higher school of technical character, wholly distinct from the traditional academic secondary school so as (1) to provide a good intellectual discipline, altogether apart from its technical

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[1] An Outline of the Structure of the Educational System in England and Wales. H.M's. Stationery Office, 1939.

[2] Report of the Consultative Committee on Secondary Education with special reference to Grammar Schools and Technical High Schools. H.M's. Stationery Office, 1939.

value, and (2) to have a technical value in relation not to one particular occupation but to a group of occupations'.

'For pupils of 13+ and onwards the curriculum should be designed to provide a liberal education with science and its applications as the core and inspiration. The subject-matter would be English, History, Geography, Mathematics, Science, Engineering Drawing, Practical Crafts in the Workshops, Physical Education and Aesthetic Subjects together with a continuation of the foreign language for those pupils capable of profiting by it.'

'In a school week of 27½ teaching hours, an average allocation of subjects in terms of hours per week might be:

English Subjects	6 hours.
Mathematics and Science	8 ,,
Workshop	4½ ,,
Engineering Drawing (including Practical Geometry)	3 ,,
Physical Training and Aesthetic Subjects..	3 ,,
Pool	3 ,,
	27½ hours.

The time required for the foreign language would be taken from the pool, and those pupils who do not take the foreign language would be given extra time from the pool for other subjects according to circumstances and needs.'

It may be mentioned that British tradition is against using the school for imparting skill in manual operations, but this tradition shows signs of breaking down. Messrs. Abbott and Wood state that 'in the present position of organized industry in India, it is essential that workshop practice shall occupy a prominent place in the curriculum of the full-time technical or industrial school. In Great Britain, where the standard of workmanship is often very high, it is possible to share the burden of training recruits to industry between the industry itself, which gives workshop experience, and the school, which teaches the scientific principles underlying workshop practice. But this plan is not suited to Indian conditions'.

If the Wardha Scheme of Basic Education is accepted, with such modifications as may be found necessary in the light of experience, a similar curriculum can be introduced in Post-Wardha Technical High Schools in India for pupils between the ages of 13 or 14+ and 16 or 17+ replacing English subjects by vernacular subjects and the foreign language by English.

As already stated the Government of India has recently started a Polytechnic at Delhi in accordance with one of the recommendations of Messrs. A. Abbott and S. H. Wood to create a first-class technical institution including a day-school for boys. As stated in the prospectus, 'the main object of the Technical High School is to provide a specialized or vocational type of education for boys desiring to enter certain specific trades or professions'.

There are two departments: Lower and Upper. The age of admission to the Lower Department will be about 10 years and education will be general, but a few periods a week will be devoted to practical instructions, e.g. workshop practice, in order to give the boys a technical or vocational outlook. The duration of the course will be four years.

The age of admission to the Upper Department will be about 14 years and the duration of the course will be three years. In this department, education will assume a more technical or vocational character but side by side with the technical training all pupils will receive a sound general education. There will be three groups for vocational subjects: (1) technical group open to boys who desire to adopt careers in Mechanical, Electrical and Automobile Engineering, Building, etc. with a view to promotion in due course to posts as charge-hands and foremen; (2) textile group to suit boys who wish to seek employment in textile mills with a view to promotion in due course to posts as jobbers and tacklers; (3) commercial group intended for pupils who desire to pursue a commercial career. This is an experiment in the right direction in so far as the secondary stage of education is concerned and the results achieved will be watched with great interest all over India.

Possibilities of organizing evening and part-time day classes in industrial centres should also be investigated. With very few exceptions like the Victoria Jubilee Technical Institute, Bombay, the Calcutta Technical School and the evening mining classes of the Mining Education Advisory Board in Bengal and Bihar, the system of evening instruction has not been developed to any considerable extent in India. In England, on the other hand, evening continuation and technical schools have been functioning with great success. Up to the end of the nineteenth century most of the technical education in England was post-elementary in character but at the beginning of the twentieth century, it was realized that to benefit from specialized technical instruction it was necessary to impart more general education than was given in elementary schools. The evening continuation schools served to bridge this gap between the elementary school and the technical school and for those pupils who did not wish to proceed to a technical school they served to broaden outlook and increase knowledge. Among other subjects grouped courses of instruction were provided for (1) industry, and (2) commerce. The industrial group usually consisted of the following subjects:

(1) Elementary Mathematics.
(2) Technical Drawing.
(3) English.
(4) Elementary Science.

During the last forty years, however, the system of secondary education has been fully established in England and boys passing out from secondary schools enter the evening technical schools directly. In India it may be quite possible to dispense with the evening continuation school altogether by the proper development of secondary education so that boys may be able to join evening technical schools which should be suitably located in large industrial centres. The courses should, however, be grouped carefully so that they may form separate and coherent units. The Annual Report of the British Board of Education for 1924-25 says:

'No highly organized structure could have been predicted for an evening school system designed to attract, and reasonably to satisfy the demand of, a large voluntary attendance of young workers. But the conception of a grouped course of study in which there is a balanced combination of subjects to be studied throughout a school year, or a succession of school years, by an attendance on two, or, more commonly with boys, three evenings a week, has from the early days of evening schools commended itself locally and centrally as a means of organizing evening study.'

Messrs. Abbott and Wood, however, recommend that 'part-time schools should be provided for the further education of young men already in employment and, if possible, the classes should be held in the day time, the students being released by their employers for two half-days a week in order that they might attend'. But it is very unlikely that employers in India would agree to this, though in other countries the present trend is to make such concessions to the employees. It may therefore, be found necessary and desirable to develop evening technical schools under existing conditions. In his book on 'Education for Industry and Commerce in England' Mr. Abbott has expressed himself very strongly in the following words:

'It is no longer fitting that young men who are taking part in a great corporate effort to raise the general standard of life in this country should be called upon to shoulder a greater proportion of the burden than that borne by older and more mature workers, and undoubtedly to call upon a youth to do a full day's work and, when that is finished and he is tired out, to spend practically every evening in study either at school or at house, is asking him to undertake more than his fair share of what we all know is a general responsibility. The release from employment of young men selected for the promise they show in order that they may attend classes on one or two half-days a week is no longer an act of philanthropy, but an act of justice.'

Before concluding this section a reference should be made to vocational guidance to draw the right workers to the right jobs.[1] 'Personality, culture, intellect, physique, all the characteristics

[1] Vocational Guidance throughout the World by Morris S. Viteles and Franklin J. Keller. Jonathan Cape, 1937.

that contribute to the making of morally excellent and dynamically effective human beings must somehow be adopted to the realities of day-to-day existence. If possible, the human beings embodying these attributes must attain not only the good life, but the happy life. Vocational guidance is the instrumentality through which these forces may become operative. A *laissez-faire* policy no longer serves to draw the right workers to the right jobs, so society must provide the collective intelligence and the co-operative agencies to guide men and women into occupations where they may best serve both themselves and others. The traditional education does not develop "occupation-intelligence" in its bewildered pupils, so the school must adopt more pertinent techniques.'

Great advances in vocational guidance have been made in other countries and psychological and other methods have been used very effectively. A study of these methods should prove very useful in the development of technical education in India.

Higher Education and Research

The aim of higher technical education is to give such a combination of humanistic, scientific and professional training as will fit the students to take leading positions in a world in which science and engineering are of basic importance. The training should be planned in University or non-University institutions to prepare practising engineers, works managers, research workers, business executives and teachers. The importance of scientifically trained men capable of handling technical as well as administrative problems cannot be over-emphasized in our world which is becoming more and more dependent on science and its applications for its everyday existence. From the purely industrial point of view it was found by the British industrialists at the Paris Exhibition in 1867 that the excellence of continental goods was due 'not to the workmen, but in great part to the superior training and attention to the general knowledge of their subjects, observable among the managers and sub-officers of industry. No candid person can deny that they are far better educated, as a rule, than those who hold similar posts in Britain'.

In his book on 'Education for Industry and Commerce in England' Mr. Abbott refers to similar conditions prevailing to-day in Great Britain and says:

'There is no doubt that if the Universities had not developed their great schools of physics, chemistry and engineering, and thus ensured a supply of men trained in scientific method, there would have been a serious dearth of men qualified to carry on industrial research. As it is, the defect is not there, but in industry itself, where in many branches there is no tradition of employing University graduates or men with wide scientific knowledge and training. In these branches, there is no real hope of applying on any adequate scale the new knowledge gained by the various research organizations until the qualifications of the men at the top have been improved.' He further says that 'since the conduct of modern industry demands for success the services of men who have not entered the works in an humble capacity at the age of 14 and made their way upwards by their own efforts, aided by study during their scanty leisure, but have had a broad general education, on which they have built a first-rate scientific education'.

Before considering the different aspects of this subject it will be useful to analyze the principal defects commonly found in the system of higher engineering education in India.

They may briefly be enumerated as under:—

(1) Insufficient and unsuitable basic preparation of students before they join higher technical institutions.
(2) Overcrowding of syllabuses.
(3) Lack of research facilities and absence of post-graduate courses.
(4) Lack of suitable modern equipment and adequate finances.
(5) Lack of continuous and close contact with industry and facilities for the practical training of students.

It has already been stated that the foundation of elementary and secondary education on which the structure of technical education rests must be strengthened before a satisfactory and efficient system of technical education can be built. The general practice in India at present is to recruit students for engineering institutions from amongst those who have passed the Intermediate Science or Arts Examinations with Physics, Chemistry and Mathematics as their subjects. The vast majority of these students are entirely unfamiliar with any kind of skilled manual work or the working of simple mechanisms. They merely carry out some routine experiments in connection with their instruction in Physics and Chemistry in science colleges or science departments of arts colleges. These courses are moreover planned with a view to provide a knowledge of pure science without much regard to its applications with the result that considerable time and effort are wasted on certain aspects of these subjects which are not of great importance to the technical man. It is therefore suggested that a place should be found at the Secondary stage of education for training in a craft requiring manual work and general science together with practical Geometry. It would then be possible to recruit students for engineering and allied courses directly after Matriculation, although instruction in Applied Physics, Chemistry and

Mathematics would have to be continued alongside with humanistic and professional courses.

Overcrowding of syllabuses is becoming a formidable problem with every advance made in science and engineering. This is particularly so in a country like India where the system of narrow specialization cannot be adopted without seriously restricting the fields of activities open to those who have completed their training. The weight not only of educational but also of industrial opinion seems to be against early or excessive specialization.

The present tendency in the United States[1] is 'for each institution to provide a considerable number of curricula, each possessing a large proportion of material which is substantially common to all, although the teaching methods and illustrations may be different with each curriculum emphasizing the particular application toward which the curriculum is directed. Thereby is obtained a freedom of choice among special fields needed to satisfy the legitimately diverse tastes of students and also some freedom of choice among subjects by the provision of electives, while an integrally conceived but flexible plan is available for each student to follow. It is, however, becoming generally accepted that such curricula should be sufficiently similar during their first two years so that students may readily transfer from one curriculum to another at the end of any term during that period'.

The chief characteristic of the present system in India is the absolute rigidity in the courses of study prescribed which can partially be explained by the administrative and financial difficulties involved in any plan providing for variety and flexibility. A further reason may be the comparatively recent growth and diversity of industry in the country. But we are now entering an era which is likely to make demands for a greater degree of specialization in professional courses than is available at present.

A further trend in the United States is the introduction of humanistic and social subjects including the arts of expression (spoken and written). Engineering faculties in the United States now generally agree on the need to dovetail engineering and political economy in the curricula so that engineering and political economy may directly and soundly influence each other, as has been done so well with engineering and the physical sciences. This trend is quite consistent with the definition of an engineer as given by Dr. Karl T. Compton, President of the Massachusetts Institute of Technology:

'An engineer is one who, through application of his knowledge of mathematics, the physical and biological sciences,

[1] Trends in Engineering Education by Dr. D. C. Jackson. *The Journal of Engineering Education*, October 1939.

and economics, and with aid, further, from results obtained through observation, experiences, scientific discovery and invention, so utilizes the materials and directs the forces of Nature that they are made to operate to the benefit of society. An engineer differs from the technologist in that he must concern himself with the organizational, economic and managerial aspects as well as the technical aspects of his work.'

It may be mentioned that at the California Institute of Technology one-fourth of the time involved in its four-year undergraduate course is spent on 'gaining familiarity with the world's best thought in literature, economics, government, history, philosophy and ethics—in a word, with world history in the broad sense of that term'. They have also introduced a section on labour relations into the department of economics because this is one of the world's most critically important problems.

The introduction of humanistic and social subjects in the syllabuses of our institutions therefore, deserves very careful consideration, although it may increase the congestion of subjects already alluded to. Engineers are now called upon to undertake larger administrative duties and responsibilities in the management and control of Railways, Municipalities, Public Utility Companies, Port Trusts, Improvement Trusts and larger industrial concerns, and in order that they may be able to do so efficiently it is imperative that these subjects should not be neglected as at present. Sufficient time for their treatment would be available in collegiate institutions if the system of secondary education is modified as suggested before. The time at present allocated to pure science subjects and to such workshop subjects as smithy and carpentry should be made available for political economy, business administration and other non-technical subjects which may be considered necessary for an engineer. The degree courses now offered by Indian Universities extend over a period of five to six years after Matriculation and this should be quite sufficient for imparting the basic knowledge of subjects necessary for the all-round training of an engineer.

The potentialities of research as an instrument for the education of engineers has not been fully realized in India. In Great Britain as well as the United States it has now been accepted, as a tenet, that research can be used very effectively in the upper years of an undergraduate course. In the opinion of Dr. D. C. Jackson, 'a notably fruitful trend in engineering education is the increasing recognition of research as a factor in such education of which the importance should be held constantly before the undergraduate upper classmen of the engineering schools, and which should be participated in by those students because competent engineering is a research occupation'. In the report on 'Policy in Technical Education', published in Great Britain in 1937, it has been stated: 'We are of opinion that, where the circumstances of the college make it possible, the development and encouragement of original investigation is of the highest importance. The fact that members of the staff and senior students are contributing to the advance of scientific and technical knowledge has a most stimulating effect upon the general body of students and adds greatly to the prestige of the college and to the esteem in which it is held by the industrial public. It affords a valuable means of contact and co-operation with industry of a character different from that obtainable through the ordinary teaching work of the college. It is of great value in keeping the teaching staff abreast of recent developments, in bringing to its teaching that freshness and originality of outlook which is essential if the best is to be obtained from the student, and in making the academic activities of the college a real and living force both within and without its walls.'

In India, however, conditions are quite different due to (1) insufficiency of staff and financial resources of institutions, (2) lack of co-operation and contact between industry and educational institutions, and (3) overcrowding of undergraduate syllabuses owing to the necessity of including a wide variety of compulsory professional subjects. The solution of these difficulties may be found in the establishment of post-graduate courses which would include research, advanced professional subjects and a foreign language other than English. The senior members of the staff should, in addition, be permitted to take a certain amount of consulting practice as in medicine, law and architecture. The Calcutta University Commission (1917–1919) has stated that 'it is held in, we believe, the majority of Universities and higher technological institutions of the present day, both in Great Britain and in America, that it is of importance to the efficiency of a technological department that its head should be kept in touch with current advances by the opportunities of private consultant practice, provided that this is not allowed to take up an undue share of his time'.

As regards suitable modern equipment and adequate financial assistance, it is hardly necessary to state that present-day technological developments are taking place at a very rapid pace and in order that instruction may not be out of date the latest equipment and machinery should be acquired for the institutions from time to time. The cost of running technical institutions is also comparatively high because of the large amount of practical and routine experimental work which has got to be undertaken even in an ordinary undergraduate course. If this is kept in mind it will be found that the majority if not all the technical institutions in India suffer from a serious paucity of funds which hampers their work at every step.

A further noteworthy trend in higher technical education abroad is the establishment of co-operative courses between the college and works. They were originally set up at the University of Cincinnati by Dean Schneider in an attempt to combine theory with actual practice. The general idea is to arrange the courses in such a manner that the students spend a part of their term time in college and a part in works. The number of fundamental and professional subjects in college is not reduced while the training in works is planned and carried out with a view to its educational value and is closely correlated with the theoretical instruction given in college. A similar system under the name of 'Sandwich System' was introduced in Great Britain some years ago with great success. Such co-operative courses can be introduced in India in the larger industrial centres, provided that the more enlightened industrial concerns offer their full co-operation. At present great difficulties are experienced by most of the colleges in arranging even for the post-graduate practical training of their students and until this is done it does not seem possible to establish any effective system of co-operative courses in India.

There is a common tendency in India to criticize engineering colleges for imparting too academic a training more or less divorced from the practical side of industry. In this connection, it may be useful to refer to the report of Sir Dugald Clerk's Committee [1] which stated that 'there is always a danger in the divorce of men with high technical and theoretical qualifications from the practical side of an industry, and our evidence shows that, with certain noteworthy exceptions, this divorce is found in engineering. In our view, the Universities ought to supply a valuable, though by no means the only, element in the administration of industry. It is, however, essential that men recruited from them should have first-hand knowledge of their fellow-workers, and this can only be secured by experience in the works as distinct from such branches as design, testing and so on'. Those in charge of technical colleges in India are alive to the importance of such practical training but, with very few exceptions, it has hitherto been found extremely difficult to make necessary arrangements for the training of students. Industry must help the colleges in order to help itself.

In addition to the desirability of using research as an instrument in the educational process, there are certain wider aspects of research which may be considered here. Systematic and continuous research on the qualities of raw materials and the most effective and economical methods of converting them into finished products is considered vital by all industrial nations for their continued prosperity and security in the present competitive age. In Great Britain the Department of Scientific and Industrial Research, the Research Associations established

[1] Education for the Engineering Industry. H.M's. Stationery Office London, 1931.

by some industries, Universities and some of the larger individual industrial concerns are engaged in programmes of active investigation concerning British industries. In India, as already stated, a Board of Scientific and Industrial Research has been established recently and if the work of this Board is to develop rapidly and the results of its researches are to be speedily and effectively applied to industry, it is imperative that the training of research workers should be undertaken in close co-operation with science and engineering colleges. This would have the effect of providing a broad and stable foundation for the work of the Board and it would, in particular, help the engineering colleges in building up a tradition for industrial research.

It would be useful in this connection to point out the desirability of expanding some of the present institutions like the Indian Institute of Science, Bangalore, and to put into effect the recommendations of the Indian Industrial Commission (1916–1918) regarding the establishment of 'Imperial colleges of the very highest grade'. They may be organized on the models of the Massachusetts Institute of Technology, U.S.A., and the Royal Technical College, Glasgow, and the subjects offered should include:

Physics, Chemistry, Mathematics, Metallurgy, Biology, Geology, Architecture, Public Health, Civil Engineering, Mechanical Engineering, Electrical Engineering, Mining Engineering, Chemical Engineering, Aeronautical Engineering, Marine Engineering, Naval Architecture, etc. in addition to non-technical subjects such as Business and Engineering Administration, Languages, Economics, etc. Such a scheme would provide centres of advanced training and research which would be open to students from all parts of India and would, in the long run, be most economical, as the subjects mentioned above are closely interrelated and workers in one field would be of great assistance to those in other fields. Laboratory and library facilities would also be shared by staff and students in all departments and a very high standard can be set in the progressive atmosphere which is bound to prevail in such institutions under the guidance of eminent men of science and technology. To vitalize its educational procedure and to fulfill its objectives the Massachusetts Institute of Technology is placing increasing emphasis on original research in pure and applied science. Their experience has demonstrated that 'teaching of the highest type, especially in science and its applications, thrives best in an atmosphere of steady progress in the understanding of the subject taught. He who is still a student, who is still himself learning, whether it be new relationships of the most fundamental scientific nature, or sounder and more economical ways of applying scientific knowledge for the promotion of industry and the public welfare, can best guide those about to enter upon a professional career'.

Considering the present trend of industrial development in India it is necessary in the field of higher education to devote more attention to the development of courses in Mechanical, Electrical, Chemical and Metallurgical Engineering. The majority of students in Indian engineering colleges are following Civil Engineering courses while in the United States,[1] according to the United States Office of Education, out of a total of 65,406 engineering college students in 1934 the distribution was as under :

Electrical Engineering	11,906
Mechanical Engineering	11,903
Civil and Sanitary Engineering	8,699
Chemical Engineering	7,533
Mining and Metallurgical Engineering ..	1,708
Naval Architecture, Marine Engineering, Agricultural Engineering, etc.	23,657

In the first term of the academic year 1938-39 one hundred and nineteen of the engineering colleges in the United States reported a total of 82,585 undergraduate students, with the increase of numbers mostly in mechanical engineering and chemical engineering. It may be interesting to note that of the foregoing total for 1934, 2,805 were post-graduate students, and in 1938 the number of post-graduate students reported was 5,175. It is imperative that a beginning should also be made immediately to establish post-graduate engineering courses in our colleges so that research may be firmly established as an indispensable element in higher engineering instruction.

Co-operation with Industry

It is hardly necessary to state that the industries of the country should first formulate their requirements before a satisfactory system of technical education can be built up. Without a conscious demand from industry and without their active and full co-operation technical education is bound to fail in its efforts to supply suitably trained personnel of the artisan, foreman or the executive type. With the exception of a few progressive industrial concerns in the country, industry on the whole has given little thought to this problem, and its co-operation and assistance, financial or otherwise, have been negligible. The house of Tatas is undoubtedly a noteworthy exception both as regards training and research, but the position in the country generally is very disappointing.

Such co-operation may be local, regional or national and may take various forms such as advisory, financial, etc. In

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[1] Present Status and Trends of Engineering Education in the United States by Dr. D. C. Jackson, 1939.

India, the position is a little difficult as most of the institutions are under the control of Government departments which are out of touch with industry and industry itself is not properly organized. These difficulties can be overcome to some extent by the establishment of a federal organization for technical education on the lines of the Federal Board of Vocational Education in the United States or the present Central Advisory Board of Education in India. We already have a similar body for medical education in the form of the Indian Medical Council which regulates courses, professional conduct, etc. National organizations of employers, employees and professional bodies, such as the Institution of Engineers, which are already in existence should also take greater and more active interest in technical education.

In England local Advisory Committees, representative, as a rule, of both employers and employed, keep in touch with the technical institution and do excellent work by ensuring that the institution and its activities maintain contact with realities. Their duties include one or more of the following: 'The visiting of classes, the discussion of curricula and staffing, the organization of lectures, the arranging of visits to works by students, the award of prizes, the gift of equipment, the encouragement of attendance, the securing of materials and equipment (either free or at special prices) and the placing of boys in employment'.

Regarding the regional organization of technical education in England Mr. A. Abbott states[1] that 'instances, drawn from different parts of the country, might be given to illustrate the manner in which individual problems, which ought to be treated singly and comprehensively, are being tackled by a multitude of authorities, each of them willing, no doubt, to co-operate with the neighbours, but unwilling to cede anything of its own autonomy. To have such a multiplicity of administrative bodies, each dealing with part of a problem and none of them seeing it as a whole, is not an efficient form of organization; moreover, it is extravagant'.

Concerning India, Mr. A. Abbott has made the following recommendations:

'Effective machinery should be established for securing close and regular co-operation between industry and commerce, on the one hand, and education on the other. This can be secured by the establishment in each province of a Government Advisory Council for Vocational Education, which would include the Director of Public Instruction, the Director of Industries, and two or three Principals of important vocational schools; on the side of business, it would include four or five business-

[1] Education for Industry and Commerce in England by A. Abbott, C.B.E. Oxford University Press, 1933.

men selected by the Government on account of their knowledge and experience of particular branches of business, and not because they represent special interests.

The Advisory Council for Vocational Education would appoint Advisory Sub-Committees dealing respectively with education for (*a*) engineering, (*b*) the textile industries, (*c*) agriculture, (*d*) small-scale and cottage industries, (*e*) other industries of major importance, (*f*) commerce.

The functions of Advisory Sub-Committees would be to draft curricula and syllabuses of instruction, to advise on equipment, to suggest where schools should be established, to visit the schools regularly, and generally to do all in their power to make their branch of vocational education successful.

Employers can help in the development of vocational education in other ways—by providing buildings, equipment, materials and funds. All these forms of assistance are frequent in Europe.'

On the side of education, as already stated, an Association of Principals of Technical Institutions (India) has been formed in July, 1941, and it is hoped that it will succeed in securing the active co-operation and assistance of Government, industrial and professional bodies in formulating a plan and policy in technical education. Before the preparation of a comprehensive scheme it may be found necessary to make a complete survey of the requirements of industries and to determine the type and extent of education necessary for the various grades of operatives needed or likely to be needed by different industries. Industrial surveys of a more or less comprehensive nature are already available for certain provinces of India and these may be found useful in determining the provision of technical education necessary for those areas. It is important, however, to reiterate that such regional schemes should definitely form part of a national plan of technical education and avoid overlapping and duplication which are common features of our system at present.

One of the most urgent needs of technical institutions in India, as already mentioned, is better facilities for training in works. Many firms, large and small, can extend their co-operation in this direction with immediate benefit to everyone concerned. Many firms in Europe and America appoint special officers to supervise the practical training of students and the training is usually planned to meet the requirements of the different categories of students. Our firms can assist by deputing one of their officers to plan and supervise the training and generally to look after the welfare of the students.

Employers can also help by adopting a more liberal policy of promotion and by encouraging the young employee in improving his work and increasing his knowledge in every possible manner. Engineering should be 'a career open to talents' and everyone entering the industry should have a chance of rising to higher positions. In the words of Sir Dugald Clerk's Committee 'it is not merely that this is in his (employer's) own interest, it is an obligation which he is under towards his young employees, towards his fellow-employers and towards the industry as a whole'.

As in England[1] 'the relation between Universities and industry is not good. Industry wants able and trained men and women, but complains that the Universities, owing to their bias against vocational instruction, do not provide them. There is no correlation of supply and demand in specialist subjects, so that graduates in chemistry are walking the streets, while there is a shortage of, say, biologists. The number of students taking full-time courses in technology in England was 4,439 in 1934, and the majority of them entered the technical (research, testing, design) rather than the production side of industry. As stated by Sir Dugald Clerk's Committee 'it will also be necessary, if more University students are to be obtained for the works, to show that there are reasonably good prospects in this direction. At present, we believe that University authorities are in serious doubt on this point and are unable to get a clear lead from employers'. These words are equally applicable to India and in order that the industries of the country may develop without avoidable delay, it is imperative to bridge the gulf between education and industry.

Conclusion

We are at present entering a new era of industrial expansion such as the European countries witnessed a hundred years ago. The present war has acted as a great stimulus for the rapid development of many new industries and the manifold expansion of those industries which were in existence at the outbreak of war. We are favoured by the many natural resources of the country and the traditions of craftsmanship which have fortunately survived the introduction of machinery. We have, moreover, numerous science institutions which are engaged in teaching and research of a very high order. The public is also alive to the vital need of industrialization of the country which is necessary for the economic prosperity and security of the people. The relation between technical education and industry is, however, not fully understood in our country and there is no clear realization of the efforts made by other countries in this important field. Public opinion should, therefore, be continuously and systematically educated about the

[1] Technical Education, issued by the New Fabian Research Bureau, London 1936.

progress made by other countries and guided about the manner in which we can profit by their experience.

In the field of technical education the most important development arising out of the present war is the Technical Training Scheme of the Government of India which is bound to exert a profound and permanent beneficial influence on our entire industrial structure. Boys with education of the Matriculation Standard are coming forward in thousands to be trained as skilled mechanics, ground engineers, wireless operators, etc., and the results so far achieved are very encouraging. They have clearly demonstrated that our boys can make excellent machinists in a comparatively short time, provided the training is so designed as to develop their inherent faculties in a systematic manner. The Bevin Training Scheme of the Government of India, under which batches of Indian workmen are sent to the United Kingdom to undergo courses of training in engineering occupations, is another step in the right direction and reports being received about their progress abroad leaves no doubt about the intelligence, adaptability and skill of our workmen for mechanical industries. The object of the Bevin Scheme is 'to accelerate munitions production in India and at the same time inculcate in the men an appreciation of British methods of industrial co-operation between employers and workers and the value of sound trade union principles'.

It is hoped that when peace returns Government will continue to take active interest in technical education and support it in every suitable way. The post-war period will bring with it many problems, one of which will certainly be the absorption by industries of technical personnel no longer required by the Defence Services. This personnel which has received and is receiving intensive training for short periods may require further instruction and training before it can be readily absorbed in the normal activities of peace-time industry. It will be necessary for this purpose to have a plan indicating the directions in which industry is likely to develop. We may have, for instance, new aircraft, shipbuilding, automobile, locomotive, machine-tool, chemical, metallurgical, electrical and other industries which, it is hoped, will be in a position to engage men released from the Defence Services. They may in addition require men with higher qualifications for design, research, testing, etc. who will have to be supplied by existing engineering colleges. The colleges themselves may have to be remodelled and improved to meet the new demands. All these problems require the closest attention now if we are not to be caught unawares when the war is over.

It is also important to state that the post-war period will witness severe competition amongst the industrial nations of the world and the very highest technical efficiency will be required of us if we are to retain the positions now being captured in the industrial field. This efficiency will depend in a large measure on the continual improvement in the technical equipment of the industrial worker. The progress of technical education, in the words of Lord Eustace Percy, 'requires the driving force of an awakened public opinion, and those who seek to awaken it will find their most powerful arguments, not in purely economic considerations but in the idea of human salvage'.

Proceedings of the Twenty-ninth Indian Science Congress

PART III—ABSTRACTS

CONTENTS

SECTION OF MATHEMATICS AND STATISTICS

President :—P. C. MAHALANOBIS, M.A., B.Sc., F.N.I., I.E.S.

Algebra

1. On some Identities.

S. C. CHAKRABARTI, Jadavpur.

1. $$\sum_{x=0}^{r} {}^{n}S_{r-x}\, {}^{m}S_{x}\, a^{nx} = {}^{m+n}S_{x} \quad \ldots \quad \ldots \quad (1)$$

where ${}^{n}S_{x}$ denotes the sum of the products of n factors $1, a, a^2, a^3, \ldots a^{n-1}$ taken x at a time.

2. Denote, for all values of n,

$$f(n, x) = 1 - \frac{a^n - 1}{a - 1}x + \frac{(a^n - 1)(a^{n-1} - 1)}{(a^2 - 1)(a - 1)}ax^2 - \frac{(a^n - 1)(a^{n-1} - 1)(a^{n-2} - 1)}{(a^3 - 1)(a^2 - 1)(a - 1)}a^3x^3 + \ldots$$

where, if n is a positive integer, the coefficient of x^r may be written as $(-)^r\, {}^{n}S_{r}$. Then

$$f(n, x) f(-n, a^n x) = 1 \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

and $$f\left(\frac{P}{r}, x\right) f\left(\frac{P}{r}, a^{\frac{P}{r}} x\right) f\left(\frac{P}{r}, a^{\frac{2P}{r}} x\right) \ldots\ldots r \text{ factors}$$

$$= f(P, x) \quad \ldots \quad \ldots \quad (3)$$

where P and r are both positive integers.

2. An Algebraic relation of higher differences.

S. C. CHAKRABARTI, Jadavpur.

Theorem.

$$\sum_{x=1}^{n} (-)^{x-1} \frac{1}{a^x - 1}\, {}^{n}S_{x} = \frac{1}{a-1} + \frac{a^2}{a^2-1} + \frac{a^3}{a^3-1} + \frac{a^4}{a^4-1} + \ldots n \text{ terms},$$

where ${}^{n}S_{x}$ denotes the sum of the products of n factors $1, a, a^2, a^3, \ldots a^{n-1}$ taken x at a time.

3. On representation of a function of two variables by partial reciprocal differences.

BHOLA SINGH *and* P. N. DAS GUPTA, Patna.

Thiele had introduced (Interpolations Rechnung, Leipzig, 1909) a system of reciprocal differences for the approximate representation of a function of a single variable by a rational function. This leads to a general method of interpolation. The present paper contemplates the extension of these differences to functions of two variables by introduction of partial reciprocal differences.

4. A note on twofold triple systems.

K. N. BHATTACHARYA, Calcutta.

We have a twofold triple system if v objects can be arranged into triplets satisfying the following conditions: (i) the three objects in any one triplet are different, (ii) each object occurs in r triplets, (iii) every pair of objects occurs in exactly two triplets. Only the following cases are possible :

$$(1)\ v = 3u+3, \quad b = (u+1)(3u+2), \quad r = 3u+2.$$
$$(2)\ v = 3u+1, \quad b = u(3u+1), \quad r = 3u.$$

Mr. R. C. Bose has shown that the general problem of the construction of twofold triple systems can be made to depend on the solution of the following combinatorial problems:

Problem A. Given an integer t, find $2t+1$ triplets of integers

$$(x_i, y_i, z_i) \qquad i = 1, 2, \ldots . 2t+1$$

such that (i) either $z_i = x_i+y_i$ or $x_i+y_i+z_i = bt+5$, (ii) among the $bt+3$ integers x_i, y_i, z_i, the integers $1, 2, 3, \ldots 3t+1$ occur exactly twice, while the integer $3t+2$ occurs just once.

Problem B. Given an integer t, to find $2t$ triplets of integers

$$(x_i, y_i, z_i), \qquad i = 1, 2, \ldots 2t$$

such that (i) either $z_i = x_i+y_i$ or $x_i+y_i+z_i = bt+2$, (ii) among the bt integers x_i, y_i, z_i each of the integers $1, 2, 3 \ldots 3t$ occurs exactly twice.

Mr. R. C. Bose has given solutions for smaller values of t, which are sufficient for the purpose, constructing those twofold triple systems which are of practical interest for the design of statistical experiments. I have in this paper obtained a general solution for the problems A and B; and this in view of Bose's results amounts to finding a general solution for the construction of a twofold triple system of any kind. Such a general solution was hitherto unknown.

Geometry

5. A note on the affine evolute.

S. M. KERAWALA, Aligarh.

A general analytical method is shown for deriving the affine natural equation of the affine evolute C_1 of a curve C from the affine natural equation of C. In particular it has been shown that the curve $ks^2 =$ const. is congruent to its affine evolute, and further that if C_1 is to be a conic, the nature of C can be found from the solution of the differential equation

$$\frac{d^2y}{dx^2} = \frac{2}{x^2y^2} - \frac{2a}{x^3},$$

where a is positive, zero or negative according as C is an ellipse, parabola or hyperbola.

6. Ruled surfaces whose curved asymptotic lines can be determined by quadratures.

RAM BEHARI, Delhi.

Picard has shown that if the generators of a ruled surface belong to a linear complex, then the curved asymptotic lines can be determined by quadratures. The determination of the asymptotic lines of some other special kinds of ruled surfaces by quadratures has also been considered by Buhl, Goursat, Srinivasiengar and Hayashi. The object of this paper is to approach the problem of finding ruled surfaces whose curved asymptotic lines can be determined by quadratures in a different way by examining certain conditions under which the Riccati's equation can be integrated.

7. An Algebraic transformation for triplicating the condition of Poncelet porism.

S. M. KERAWALA, Aligarh.

Assuming the two conics to be reduced by means of a homographic transformation to two circles of radii r and R with their centres d apart, Chaundy proves with the help of elliptic functions that the porism of a $(2n+1)$-gon is converted into the porism of a $(4n+2)$-gon of the separable case by an interchange of R and d. In this paper it has been proved without any use of elliptic functions that the porism of an n-gon is converted into the porism of a $3n$-gon by writing

$$\frac{2R}{(R^2-d^2-2Rr)^2} \text{ instead of } R;$$

$$\frac{(R+r-d)}{(R^2-d^2+2rd)^2}+\frac{(R+r+d)}{(R^2-d^2-2rd)^2}-\frac{2R}{(R^2-d^2-2Rr)^2} \text{ instead of } r;$$

and
$$\frac{(R+r+d)}{(R^2-d^2-2rd)^2}-\frac{(R+r-d)}{(R^2-d^2+2rd)^2} \text{ instead of } d.$$

8. An affine analogue of Singer's Theorem.

R. C. BOSE, Calcutta.

James Singer by considerations of Finite Geometry proved the following theorem on the theory of numbers: Given an integer m of the form p^n (p being a prime), we can find $m+1$ integers,

$$d_0, d_1, \ldots\ldots, d_m$$

such that among the $m(m+1)$ differences d_i-d_j $(i, j=0, 1, \ldots m, i\neq j)$ reduced modulo m^2+m+1 the integers $1, 2, \ldots, m^2+m$ occur exactly once. This gives him the following compact representation of the Finite Projective Geometry $PG(2, p^n)$: If the integers $0, 1, 2, \ldots, m^2+m$ are regarded as points of $PG(2, p^n)$, then the m^2+m+1 sets of collinear points are given by

$$d_0+i, d_1+i, \ldots\ldots, d_m+i \mod (m^2+m+1)$$

$i=0, 1, 2, \ldots, m^2+m.$

I have obtained the following result which may be considered as the affine analogue of Singer's Theorem: Given an integer m of the form p^n (p being a prime), we can find m integers,

$$d_1, d_2, \ldots\ldots d_m$$

such that among the $m(m-1)$ differences $d_i - d_j$ ($i, j = 1, 2, \ldots m$, $i \neq j$) reduced modulo m^2-1, all the integers less than m^2-1, and not divisible by $m+1$, occur exactly once. This gives us the following compact representation of the Finite Affine Geometry $EG(2, p^n)$: If the integers $0, 1, 2, \ldots m^2-1$ together with the adjoined number ∞ be regarded as the points of $EG(2, p^n)$, then the m^2+m sets of collinear points are given by

(i) $d_1+i, d_2+i, \ldots\ldots, d_m+i \mod (m^2-1)$
$i = 0, 1, 2, \ldots, m^2-2$.
(ii) $\infty, \quad j, \quad q+j, \quad 2q+j, \ldots\ldots (m-2)q+j$, where $q = m+1$,
$j = 0, 1, 2, \ldots, m$.

It is now well known that $p^{2n}-1$ degrees of freedom involved in the contrasts between p^{2n} objects can be split up into p^n+1 independent sets of p^n-1 degrees of freedom each, each set representing comparisons among p^n groups of p^n objects. This splitting is usually done by using completely orthogonalized sets of Latin Squares. From the connection established by me in a previous paper between such sets and $EG(2, p^n)$ it is obvious that the compact representation derived above solves this problem with the greatest ease.

9. On a certain quartic surface related to a pair of given lines and a pair of given quadrics.

N. CHATTERJI, Patna.

The questions of a straight line $\Sigma ax+d = 0$ and $\Sigma a'x+d' = 0$ contain six parameters. If the line be subjected to one condition, e.g. to cut two given conicoids in four points in anharmonic ratio, we get a relation among the parameters. If, therefore, $(abcd)$ and $(a'b'c'd')$ are functions of two parameters, it is possible to eliminate and obtain a ruled surface which is of the fourth degree. We can easily make $(abcd)$ and $(a'b'c'd')$ functions of two parameters if the line is required to cut two given lines which may be conveniently represented by $x = 0 = y$ and $z = 0 = t$. Through every point on either of these lines there are, in general, two transversals satisfying the conditions but these two transversals coincide for four particular positions of the point. In this paper the relationship of these four points with respect to the given conicoids and lines has been investigated as also the peculiar properties of the ruled quartic surface which is the locus of the transversals.

10. On Latin and Hyper-Graeco-Latin cubes and hyper-cubes.

K. KISHEN, Cawnpore.

We may define an s-sided m-fold ($m = 3, 4, \ldots$) Latin hyper-cube of the *rth order*, $r<m$ as an m-fold hyper-cube arrangement of s^m letters, s^{m-r} of each of s^r kinds, such that each letter occurs exactly s^{m-r-1} times in each of the m sets of $s(m-1)$-flats, parallel to the m co-ordinate $(m-1)$-flats $OX_1X_2 \ldots\ldots\ldots X_{m-1}$, $OX_1X_2 \ldots\ldots X_{m-2}X_m, \ldots\ldots$ $OX_1X_2 \ldots X_{i-1}X_{i+1} \ldots\ldots X_m, \ldots\ldots OX_2X_3 \ldots\ldots\ldots X_m$. Two such Latin hyper-cubes, one superimposed on the other, such that every

letter of the one occurs exactly s^{m-2r} times with every letter of the other, may be said to be orthogonal to each other. Evidently $r \leqslant \frac{m}{2}$ denoting letters of the first hyper-cube by Latin letters and those of the second hyper-cube by Greek letters, the composite hyper-cube may be said to constitute an m-fold Graeco-Latin hyper-cube of the *rth order*.

It has been shown in this paper that Latin cubes ($m = 3$) and hyper-cubes ($m>3$) of the *first order* of any side exist and that s-sided m-fold Latin hyper-cubes of the *rth order* ($r \leqslant m-1$, the sign of equality not holding in certain cases) also exist, s being a prime positive integer or a power of a prime. It has further been demonstrated that the existence of an s-sided m-fold Hyper-Graeco-Latin hyper-cube of the *first order* is exactly equivalent to the existence of the finite hyper-dimensional projective geometry $PG(m, s)$, whence it follows that the total number of m-fold Latin hyper-cubes of the *first order* constituting an s-sided m-fold completely orthogonalized Hyper-Graeco-Latin hyper-cube of the *first order* is $s^{m-1}+s^{m-2}+\ldots+s^2+s-(m-1)$.

Theory of Functions

11. A note on the divergence theorem.

C. Racine, Madras.

The proofs generally given of this theorem (see for instance: Kellog, Potential Theory, Springer) are simple when the domain is simple and the derivatives, up to the second order, continuous in the domain, but extremely complicated in more general cases. In this paper a method of 'direct Geometry' in the sense defined by Prof. Bouligand is proposed which leads without much complication to a general result.

The conditions are: the domain is bounded by a curve which may be obtained as the limits of polygons in a vicinity of the first order. The function must have partial derivatives of the first order continuous in the domain. Further

$$Df(x, y) = \lim_{\substack{h\to 0\\ k\to 0}} \left\{ \frac{f(x+h, y)+f(x-h, y)-2f(x, y)}{h^2} + \frac{f(x, y+k)+f(x, y-k)-2f(x, y)}{k^2} \right\}$$

must exist in the domain and be continuous. Finally the normal derivatives at points of the boundary must exist, at least as a limit, and be Lebesgue integrable.

12. An integral involving Humbert Functions.

R. S. Varma, Lucknow.

In this paper an integral involving Humbert Functions defined by the relation

$$J_{m,n}(x) = \frac{(x/3)^{m+n}}{\Gamma(1+m)\Gamma(1+n)}\, {}_0F_2\left(m+1, n+1\,;\ -\frac{x^3}{27}\right)$$

is investigated. This is done by the help of Operational Calculus. Special cases of this general result gives integral equations for Humbert Functions.

13. Determination of the jump of a function by its Fourier Series.

R. N. MOHANTY, Cuttack.

Let a periodic function of period 2π be Lebesgue integrable in the interval $(-\pi, \pi)$ and let its Fourier Series be

$$f(t) \sim \frac{1}{2} a_0 + \sum_{n=1}^{\infty} (a_n \cos nt + b_n \sin nt).$$

We write

$$S_n(x) = \frac{1}{2} a_0 + \sum_{\mu=1}^{n} \left(a_\mu \cos \mu x + b_\mu \sin \mu x\right) \equiv \sum_{\mu=0}^{n} c_\mu(x)$$

$$\bar{S}_n(x) = \sum_{\mu=1}^{n} \left(b_\mu \cos \mu x - a_\mu \sin \mu x\right) \equiv \sum_{\mu=1}^{n} \bar{c}_\mu(x),$$

$\bar{S}_n(x)$ being the trigonometrical polynomial conjugate to $S_n(x)$.

Let $\bar{S}_n^\alpha(x)$ denote the nth Cesaro mean of order α of the sequence $\bar{S}_n(x)$.

Let $D(x)$ be a number such that

$$\psi(t) = f(x+t) - f(x-t) - D(x)$$

and, for $t > 0$, write

$$\Psi_\alpha(t) = \frac{1}{\Gamma(\alpha)} \int_0^t (t-u)^{\alpha-1} \psi(u)\, du, \qquad (\alpha > 0),$$

$$\Psi_0(t) = \psi(t), \quad \Psi_\alpha(t) = \Psi'_{\alpha+1}(t), \qquad (-1 < \alpha < 0),$$

$$\psi_\alpha(t) = \Gamma(\alpha+1) t^{-\alpha} \Psi_\alpha(t), \qquad (\alpha > -1).$$

The object of this paper is to prove that

if $$\int_0^t \left| \psi_\alpha(\tau) \right| d\tau = O(t) \quad \text{and} \quad \psi_{\alpha_H}(t) = o(t) \qquad \text{as } t \to 0$$

then $$\lim_{n \to \infty} n^{-\xi\alpha} \left\{ \left[\bar{S}_{2n}^\beta(x) - \bar{S}_n^\beta(x) \right] - \frac{1}{\pi} \log 2D(x) \right\} = 0$$

$$\text{for} \qquad \beta > \alpha \geqslant 0$$

$$\text{and} \qquad \xi > \eta = k/\alpha,$$

where k is the integer next to α.

Chow's extension of Szasz's theorem is the case $\alpha = 0$ of the present theorem (*J.L.M.S.*, **16**, Pt. I, 1941).

Further the theorem has been extended for the case $-1 < \beta < 0$ in the present paper.

Hydrodynamics

14. Viscous solutions obtained by superposition of effects.

B. R. SETH, Delhi.

No attempt seems to have been made to obtain the solution for a solid moving uniformly through a viscous liquid by superposing a suitable solution on the corresponding solution when the liquid is non-viscous. The application of this method to some well-known cases gives some interesting results. It is found that the suitable solution in the case of a sphere is that due to a concentrated force $6\mu\pi aU$ applied at the centre, and in the case of a circular cylinder that due to a concentrated force $4\mu\pi U$ applied at its centre. The concentrated force in each case is equal to the drag suffered by the body.

Astronomy and Astrophysics

15. The solar motion.

P. SAMUELS LALL, Lahore.

1. Material used and method employed.
2. Solar motion results for stars of the various spectral types.
3. The K-term and probable errors.
4. Comparison with other results.
5. Vertex locus.
6. Possible causes for the existence of the vertex variations of the solar motion results for the bright stars of different spectral types.

16. White dwarf and harmonic oscillator.

F. C. AULUCK, Lahore.

As is well known, the *cold* stellar bodies, viz. white dwarf stars and planets, have provided one of the most fertile fields for the application of the new Quantum Statistics. It was realized that under certain simplified conditions, the state of an electron inside a *cold* stellar mass could be represented by the wave-functions of a simple harmonic oscillator and a further development of this idea led to a discussion of the usual (i.e. non-relativistic) and the relativistic harmonic oscillator subject to artificial-boundary conditions. The fundamental formula of the white dwarf theory has been derived from the standpoint of the bounded oscillator. When the relativistic theory of the oscillator is used, it is found that, for a mass exceeding a critical mass M_0, the radius of the equilibrium configuration tends to vanish.

17. The origin of the solar system.

A. C. BANERJI, Allahabad.

The theories of Jeans and Jefferys have failed to explain the distribution of angular momentum in the solar system. It appears to be highly improbable, if not impossible, that so much angular momentum can be put into the ejected material from the Sun by the passing star during the encounter. It has been suggested that our Sun might have been a binary star having a companion much smaller than itself. A collision between this companion and a passing star broke the former into fragments which were condensed into the present planets. Russell abandons this hypothesis as unpromising as it is not possible to explain satisfactorily how the companion of the Sun was got rid of and how the collision could break up a single mass into several planets of comparable size. Lyttleton tried to give a mathematical treatment of the above suggestion. He studied the particular case in which the masses of the three stars were equal. Luyten and Hill showed that if a planetary ribbon be formed between the Sun's companion and the intruding star, then about 94% of the total length of the ribbon, would be retained by these two stars and only 6% of the filament becomes available for possible capture by the Sun and subsequent formation into planets. The difficulty about the distribution of angular momentum is also not solved. Luyten further pointed out that if the intruding star be much more massive than the Sun then the latter would itself be captured by the massive star. In a recent paper P. L. Bhatnagar has shewn that even in the most favourable case there is hardly any possibility of the formation of the planetary ribbon, and in such cases the collision between the Sun, its companion and the intruding star cannot be avoided. On the other hand, Spitzer has shewn from astrophysical considerations that even if the ribbon is formed it will diffuse in space without giving birth to any planets.

Eddington and Sterne have considered the small radial oscillations of a variable star under adiabatic condition, and the squares of amplitude were neglected. The oscillations in such cases subsist. On the other hand, if terms containing squares of amplitude are kept, it can be dynamically proved by taking suitable laws of variation of density with distance that motion becomes unstable, amplitude ultimately becomes very large, and oscillations ultimately die out.

It is assumed that in the beginning our Sun was a Cepheid variable having small radial pulsations. A passing star (which need not come very near) increased the amplitude by producing tidal disturbance. The motion became unstable and matter was thrown out to planetary distances. When the planets were formed the attraction of the passing star set them moving sidewise. It is further shewn that sufficient subatomic energy can be obtained from thermonuclear reactions for ejection of matter to planetary distances.

Statistics

18. On an aspect of the Pearsonian system of curves and a few analogies.

B. C. Bhattacharyya, Dacca.

The distributions of χ^2 and a few function of χ's reproduce at least six of the seven principal types of the Pearsonian system of curves. By analogy distributions of a few more simple functions of χ's have been worked out (in addition to other interests that they may have) in search of patterns for graduation curves. Two of these yield the curves put forward by McKay in 1932, which have already been examined elsewhere by the writer from the point of view of practical application. Among other distributions, one appears to be promising and the writer hopes to give the results of a detailed examination of it shortly.

19. On the power function of a test of significance for the difference between two proportions.

C. Chandra Sekar and S. P. Agarwala, Calcutta.

The conception of power function introduced by Neyman and Pearson not only serves as a basis for discriminating between alternative tests of significance but is also of great value in planning experiments when the test of significance to be used is decided beforehand. In this paper the hypothesis that two samples of equal size are drawn from the same binomial population has been considered and on the assumption that the test of significance to be used is the same as the exact test for homogeneity in a fourfold contingency table, its power function for different values of the sample size has been worked out. The utility of the power function in deciding the sample size so that a real difference between two binomial populations can be detected in a given proportion of experiments is illustrated.

20. Certain multivariate generalizations of analysis of variance and certain associated problems of classification.

S. N. Roy, Calcutta.

The author, along with others working independently, gave in 1939 a partial solution of the problems of discrimination between (A) 2 multivariate normal populations in respect of variances and covariances associated with the different characters, (B) K multivariate normal populations in respect of the means of the several characters (on the hypothesis of the same set of variances and covariances for different populations). A similar set of p statistics (for p-variate populations) were proposed by all the workers as being suitable for the discrimination problem in both (A) and (B); the sampling distribution of this set of p was found to be the same for both (A) and (B).

In 1940 the author worked out the sampling distribution of this p set on the non-null hypothesis in respect of (A), giving thus a partial solution of the problem of classification connected with (A), which was offered at the last Science Congress. In 1941 the author obtained on the non-null hypothesis for (B) the sampling distribution of the p-set yielding similarly a partial solution of the classification problem for (B). The sampling distribution in these two cases were, however, entirely different.

The present paper gives in the first place this partial solution of the classification problem for (B), and later on, by considering suitable functions of the p-set rather than the set itself, it gives much better and physically more cogent methods for both discrimination and classification with regard to each of the situations (A) and (B).

21. Distribution and use of part correlation.

S. N. Roy *and* G. D. Mathur, Calcutta.

The coefficient of partial correlation is employed to measure the correlation in a hypothetical universe, from which all variation due to changes in the eliminated factors has been excluded. But in most of the economic phenomena such a hypothetical universe does not exist. B. B. Smith and Ezekiel have considered another coefficient, termed as part correlation, to measure the correlation in the actual universe. With the coefficient of part correlation all of the original variation in the independent factor is left intact, and only the dependent factor is adjusted.

If $x_1 = b_{12.34\ldots n}x_2 + b_{13.24\ldots n}x_3 + \ldots\ldots + b_{1n.23\ldots n-1}x_n$

then the correlation between

$$(x_1 - b_{13.24\ldots n}x_3 - b_{14.23\ldots n}x_4 - b_{1n.23\ldots n-1}x_n)$$

and x_2 is termed as the part correlation between x_1 and x_2.

In the present paper the authors have attempted to find out the distribution of the part correlation assuming that the variables $x_1, x_2 \ldots x_n$ are distributed normally. To the best knowledge of the authors this distribution has not been worked so far.

22. The specification of demand curves.

G. D. Mathur, Calcutta.

Marshall, Moore, Schultz and others have considered different types of Static Demand Functions and have popularized one or the other form.

Frederick Roos has given a mathematical set up for the Dynamic Demand Functions under conditions of time-lags and speculation. But so far no systematic attempt has been made to determine why a demand decision curve should take the form postulated. In this paper an attempt has been made to pursue these questions by analyzing further the conceptions of demand behaviour.

Varying forms of Static Demand Functions have been given on the assumption that (1) with increasing prices the rate of decrease of demand decreases, and (2) with decreasing prices the rate of increase of demand increases. In certain cases and at certain stages of economic equilibrium these assumptions may not be valid. For this purpose a new type of curve has been suggested which fulfils the above conditions for some points of equilibrium and for other points the conditions are reversed, i.e. with increasing prices the absolute rate of change of demand increases and with decreasing prices the absolute rate of change of demand decreases. This curve is of the form $xy^2 = a(b-x)$ and satisfies nearly all possible combinations of demand situations.

23. Balanced partial confounding of interactions in asymmetrical factorial designs.

K. R. Nair, Calcutta.

If the different numbers of levels $p, q, r, \ldots$ of the several factors in an asymmetrical factorial design are such that at least two factors are at S levels, where S is a prime integer or power of a prime, the design may be denoted, for our purpose, as one of the $k \times S^n$ type, where k and n are any integers other than 1. In this paper I have shown that for such a type of design, the block size could be reduced to kS^2 plots without affecting any of the main effects but partially confounding some of the interactions. If the block size is increased to kS^2 plots and if $2<n \leqslant S+1$, the first order interactions can be wholly preserved, like the main effects. The minimum number of replications required, in either case, for a balanced design is $\geqslant k$ and is always one less than certain power of S. Thus for $n = 2$, the number of replications will be $S-1$ if $k<S$; S^2-1 if $S<k<S^2$; S^3-1 if $S^2<k<S^3$; and so on.

The only published solutions for this problem are when k and S have either of the values, 2 or 3. They were given by Dr. F. Yates who, however, did not indicate the underlying theory of the method of construction of his designs. In this paper I have enunciated the necessary and sufficient condition for the existence of a balanced design in the general case. I have also given methods of construction of these designs and of statistical analysis of the data obtained by using them in field experimentation.

24. On the reduction formulae for the incomplete probability integral of the multiple correlation coefficient of the second kind.

Purnendu Bose, Calcutta.

The distribution of the multiple correlation coefficient of the second kind was obtained by Prof. R. A. Fisher as

$$G(n, n, p) = \frac{2\left|\overline{\frac{n-1}{2}}\right.}{\left|\overline{\frac{p-1}{2}}\right.\left|\overline{\frac{n-p}{2}}\right.} \frac{1}{{}_1F_0\left(\frac{n-1}{2}, \beta\right)} x^{\frac{p-3}{2}} (1-x)^{\frac{n-p-2}{2}}$$

$$\times {}_2F_1\left(\frac{n-1}{2}, \frac{n-1}{2}, \frac{p-1}{2}, \beta x\right).$$

The final reduction forms are

$$G(n,\ 4,\ 2) = 2x^{\frac{1}{2}} \frac{{}_1F_0\left(\frac{n-1}{2},\ \beta x\right)}{{}_1F_0\left(\frac{n-1}{2},\ \beta\right)}$$

$$G(n,\ 5,\ 3) = 2x \frac{{}_1F_0\left(\frac{n-1}{2},\ \beta x\right)}{{}_1F_0\left(\frac{n-1}{2},\ \beta\right)}$$

$$G(n,\ 4,\ 3) = \frac{1}{{}_1F_0\left(\frac{n-1}{2},\ \beta\right)} \left[B_x\left(1,\ \frac{1}{2}\right) + k_1 B_x\left(2,\ \frac{1}{2}\right) + \ldots\ldots\right]$$

$$G(n,\ 3,\ 2) = \frac{1}{\pi\, {}_1F_0\left(\frac{n-1}{2},\ \beta\right)} \left[B_x\left(\frac{1}{2},\ \frac{1}{2}\right) + k_1' B_x\left(\frac{3}{2},\ \frac{1}{2}\right) + \ldots\ldots\right].$$

With the help of the above reduction forms we can construct tables for the original distribution function.

25. On discrimination and divergence.

A. Bhattacharyya, Calcutta.

The problem of discrimination and grouping in statistics is not a new one. The D^2-statistic or Mahalanobis's generalized distance tries to estimate the divergence Δ^2 between two multivariate normal populations.

We here define a measure Δ^2 of divergence of two multinominal populations characterized by the population proportions (π_i), (π_i'): $i = 1, 2, \ldots k$, where

$$\cos \Delta = \sum_{i=1}^{k} \sqrt{\pi_i \pi_i'}.$$

The corresponding sample estimate D'^2 is given by

$$\cos D' = \sum_{i=1}^{k} \sqrt{p_i p_i'},$$

(p_i) and (p_i') being two samples from the two populations.

In every large sample (of sizes n and n' respectively) the probability function of D'^2 asymptotically approaches

$$\text{const. } e^{-\frac{2nn'}{n+n'}(D'^2 + \Delta^2)} \, . \, D^{\frac{k-2}{2}} \, I_{\frac{k-3}{2}}\left(\frac{4nn'}{n+n'} D'\Delta\right).$$

In the case of two continuous populations with probability functions $\phi(x_1, x_2, \ldots x_p)$, $\psi(x_1, x_2, \ldots x_p)$ the population divergence becomes

$$\cos \Delta = \int \sqrt{\phi \, . \, \psi} \, . \, dx_1 dx_2 \ldots dx_p.$$

Some particular cases have been considered in this paper and it is found that they are not inconsistent with previous notions.

26. On some methods of random sampling in a region having some known characteristic.

BIRENDRANATH GHOSH, Calcutta.

In problems of sampling in a geographical region the conceptions of population set (P.S.), representative population set (R.S.), and sample set (S.S.) of points are fundamental. In the simplest case conditions of homogeneity and isotropy in the R.S. are to be observed and x, y-randomization offers a method for choosing the S.S. In the case of previous knowledge of some relevant characteristic ϕ, x, y-randomization is generally not suitable. Help of ϕ-lines and ψ-lines (which may be the grad-ϕ lines) are to be taken. The Jacobian $J(\phi, \psi)$ may be called intrinsic weight, while $K(\phi, \psi)$ is the extrinsic weight depending on the enquiry, and resultant weight $R(\phi, \psi) = J \times K$. With the introduction of the extrinsic weights, the pure R.S. is changed to the modified representative set (M.S.) of points. Cases when ϕ, ψ are separable in $R(\phi, \psi)$ can be tackled by randomizing independently in terms of ϕ and ψ. If they are not so, ϕ should be randomized *first* and *then* ψ, the latter depending on the former. These methods have been illustrated where the ϕ-lines and ψ-lines are respectively families of various regular geometrical curves. Even when they are not so an empirical procedure has been developed.

The present problem is allied to the more general problem of Non-Random Fields, which is being studied by Prof. P. C. Mahalanobis.

27. On devising an efficient sampling technique for forecasting the mean value of a variable.

P. C. MAHALANOBIS *and* (MRS.) CHAMELI BOSE, Calcutta.

In problems of sampling, the mean value (η) of a character (y) from a given population (π) can be estimated from a sample randomly drawn from the said population with some margin of error.

But, if it is not possible to measure the character (y) directly, then the mean value (η) of the population (π) can be estimated with a certain precision by the help of a second character (x_1). There may be many other characters (x_2, x_3, ... x_n) or any linear function of these values by which the mean value (η) of this character (y) can be estimated separately from a sample drawn randomly from the said population with different order of precisions.

From these characters (x_1, x_2, ... x_n) it can be found out which will give the best estimate of the mean value (η) of the character (y) but for a rigorous solution of this problem of developing an efficient method of estimating the mean value (η) of the character (y) it is, however, necessary to obtain data regarding the relative cost of field operations.

In the present paper the authors have attempted to develop an efficient method for estimating the mean value of a character so that the maximum information can be obtained with minimum cost.

28. On the rupee census problem.

P. C. MAHALANOBIS *and* N. T. MATHEW, Calcutta.

In this paper a new method of estimating the volume of Rupee Circulation has been developed by maximizing the mathematical likelihood of a sample.

If N_{it} be the number of coins minted in the i-th year which survive up to the t-th year, then

$$N_{it} = N_{ii}\, l^{-r(t-i)},$$

where r is the rate of absorption.

The probability of obtaining a sample $(n_{1t}, n_{2t}, \ldots n_{tt})$ is

$$\frac{\left(\sum_i n_{i_t}\right)!}{\prod_i (n_{it})!} \; \frac{\prod_i N_{it}^{n_{it}}}{\left[\sum_i N_{it}\right]^{\sum_i n_{it}}}$$

which is maximum when

$$\sum_i i p_{it} = \frac{\sum_i i N_{it} l^{ri}}{\sum_i N_{it} l^{ri}}, \quad \text{where } p_{it} = \frac{n_{it}}{\sum_i n_{it}}.$$

This provides an equation for the estimation of r and hence the total circulation.

The method has been applied for the estimation of the Rupee Circulation in India for the period 1881–1940. The question of an adequate sampling technique has also been investigated.

29. Sample survey of public opinion.

P. C. Mahalanobis, Calcutta.

This paper gives a general account of recent experiments conducted by the Indian Statistical Institute in using the sample survey for ascertaining public opinion.

30. Enquiry into the family budgets of labourers in Bengal.

P. C. Mahalanobis *and* K. Gupta, Calcutta.

The modern principles of randomization and statistical control are being used with good effect in an enquiry into labour family budgets in Bengal which is being conducted by the Indian Statistical Institute on behalf of the Bengal Board of Economic Enquiry. The present paper gives a general description of the statistical methods and controls used in this enquiry. An account also is given of the methods followed in the matter of grading various goods and services and collection of prices of the same which would make possible comparison of labour conditions in different areas.

31. The analysis of partially balanced and symmetrical unequal block arrangements with missing plots.

K. Kishen, Cawnpore.

The partially balanced designs introduced by Bose and Nair (1939) and the symmetrical unequal block arrangements by Kishen (1939), of use in agronomic tests involving a large number of varieties, are generalizations of the symmetrical incomplete block designs and two-dimensional lattices with equal or unequal groups of sets worked out in recent years by Yates. The appropriate procedures of statistical analysis have been given by the authors in their respective papers.

In case, however, one or more missing values occur by accident, the appropriate analytical procedure in either case ceases to be applicable. Besides estimation of the missing values by the usual procedure of minimizing intra-block error variance, it then also becomes necessary, for a valid test of significance of differences among varieties, to correct the sum of squares due to varieties as obtained by the appropriate statistical procedure from reconstructed data. In this paper estimates of missing values for partially balanced and symmetrical unequal block arrangements have been worked out, and expressions for the correction of varietal sums of square for a single missing value have been given as also standard errors of varietal differences.

32. On expressing single degrees of freedom in 3^5, 4^4 and 5^3 factorial arrangements in terms of their main effects and interactions.

K. KISHEN, Cawnpore.

In a previous communication, presented to Fourth Session of the Indian Statistical Conference, January 1941, the author gave a general method of expressing any single degree of freedom for treatments in terms of sets of treatment combinations for main effects and interactions. It was shown that the method follows as a direct corollary to Bose and Kishen's method of representation of treatment combinations in the general symmetrical factorial arrangement by points in the associated finite hyper-dimensional projective geometries.

In the previous paper, this method has been utilized to work out expressions for single degrees freedom belonging to the second and higher order interactions in terms of the sets of treatment combinations for interactions of the corresponding orders for 3^4 and 4^3 factorial arrangements. In the present paper, similar work has been done for 3^5, 4^4 and 5^3 factorial designs.

33. On a method to test the accuracy of birth registration.

B. N. DATAR, Calcutta.

This is a paper giving the results of some of the investigations in connection with the Baroda State Census of 1941. An article with the same title was published by Mr. S. V. Mukerjea in the 1931 report basing his observations on methods described in Newsholme's Vital Statistics. A significant correlation was found between births in a particular year and the rainfall in the previous year, as also the cost of living index. The residual variance in births after taking account of the time factor as also the variables above mentioned (viz. cost of living index, and rainfall), compared to the total variance, gives a useful criterion for the accuracy of birth registration. Results obtained by this method have been compared with those obtained by Newsholme's method as given in 1921 and 1931 Census Reports of Baroda State.

SECTION OF PHYSICS

President:—B. B. Ray, D.Sc., F.N.I.

Atomic and Nuclear Physics

1. On the production of mesotrons by non-ionizing agents in cosmic rays.

S. C. Sirkar *and* S. K. Ghosh, Calcutta.

Several workers repeated the Rossi-Hsiung type of experiment and came to the conclusion that the increase in the number of threefold coincidences with the shift of an absorber from its position between the two upper counters to the top of the counters might be due to the production of mesotrons by non-ionizing agents in cosmic rays. Rossi, Janossy, Rochester and Bound (*Phys. Rev.*, **58**, 761, 1940) studied the problem at sea-level using an extra counter above the threefold coincidence telescope and recording simultaneously the threefold and fourfold coincidences with an absorber placed alternately between the second and the third and between the first and the second counter. They concluded from the results observed by them that the increase in the number of coincidences with the shift of the absorber was due to side showers.

The present authors have studied the same problem in the Palit Laboratory of Physics, University College of Science, Calcutta, using an anti-coincidence circuit in which four counter systems formed a vertical telescope and only the coincidence of the lower three counters not accompanied by a discharge of the topmost one could be recorded. Such anti-coincidences were observed to increase by 2% with the shift of the absorber mentioned above even when an extra absorber of lead, 20 cm. thick, was placed permanently above all the counters. Without this absorber the said increase was 5%. The results are discussed and it is concluded that the former increase may be due to production of mesotrons by 'neutrettos' alone and the latter by neutrettos and energetic photons.

2. On the collision of meson by electron.

S. Gupta *and* R. C. Majumdar, Calcutta.

The collision cross-section of a meson with an electron is calculated for different values of meson spins from the quantum electrodynamics. It is found that the spin has not any appreciable effect even at an energy of 10^{10} e.v. for low value of energy transfer and the cross-section decreases to zero for an energy transfer of nearly half the incident energy of the meson. For higher energy, at 10^{11} e.v., the cross-section for spin one first increases reaching a maximum when the energy transfer is nearly one-third of the incident energy and then decreases. For the extreme high energy the difference in spins plays an important part and the correction due to spin increases very rapidly with the energy as well as the energy transfer of the incident meson and becomes very large when the energy transfer to the electron is nearly complete. This characteristic increase with the incident energy is due to the longitudinally polarized meson going over to the transversely polarized state after the collision with the electron or vice versa. The results are applied to study the cosmic ray showers produced by the meson. The validity of the theory in this ultra relativistic region is discussed.

3. On the multiple scattering of meson by Coulomb field.

R. C. Majumdar *and* S. Gupta, Calcutta.

The scattering of meson by the Coulomb field has been calculated for different values of spins of the meson. The contribution from the effect of the finite size of the nucleus and the screening of the nucleus by the atomic electrons to the scattering has been estimated. The results are then subjected to the statistical treatment to find out arithmetic mean deflexion when the scattering is multiple. The theoretical values are compared with the experimental results of Blackett and Wilson on the scattering of cosmic ray particles by the metal plates.

4. The elastic scattering of neutrons by deuterons.

C. K. Sundarachar, Bangalore.

The experimental study of the scattering of neutrons in deuterium carried out by the author in collaboration with J. F. Streib at the California Institute of Technology, using the neutrons released in the Be-D nuclear reaction, reveals a prominent maximum at 0·7 Mev., in the distribution-in-energy curve of the recoil deuterons. A similar anomaly has been observed for neutron scattering in helium at about one Mev. by Staub and Stephens and ascribed to a resonance scattering arising from the formation of a compound nucleus. A less marked anomaly at 2 Mev. predicted by Feenberg for the scattering of protons by protons and found recently by Heydenberg and Ramsey is presumably due to the lower limit for the repulsion arising from the saturation of exchange forces. The peak at 0·7 Mev. detected by Streib and the present author, in the case of scattering of neutrons by deuterons, may correspond to the 'Ramsauer effect' deduced by Massey and Mohr (*Proc. Roy. Soc.*, A, **148**, 206, 1935) on the basis of a potential, in which case the radius of the potential well will be about $4{\cdot}5 \times 10^{-13}$ cm. The anomaly in the scattering may also be interpreted to correspond to the critical wave-length of $5{\cdot}4 \times 10^{-13}$ cm., deduced by Bethe from a continuum theory of the compound nucleus. Arguments based on the experimentally discovered quadrupole moment of the deuteron and the low value of the D wave function led Schwinger to establish a lower limit of $2{\cdot}5 \times 10^{-13}$ cm. for the range of nuclear interaction. It would appear, therefore, as stressed recently by Massey and Buckingham (*Nature*, **146**, 776, 1940) that a more extensive set of experimental data will be needed to decide on the exact type of fundamental nuclear forces.

5. Transformation of Schroedinger solution in momentum space and its relation to hydrogen problem.

S. Bose, Dacca.

The abstract theory of Quantum Mechanics postulates the possibility of exclusively using momentum variables in all investigations concerning stationary states of atomic systems. As this alternative method brings into prominence the energy and momenta of the system, and eliminates automatically all references to space-variables it appears in many cases as the more desirable procedure to follow. To test the possibility of the method, the calculation for the stationary states of the hydrogen atom has been worked out. The usual procedure of replacing space-variables by differential operators of the momentum space, i.e.

$$\left(q\text{'s by } \frac{h}{2\pi i}\frac{\partial}{\partial p}, \text{ etc.}\right),$$

is not applicable in this particular case, due to the presence of $\frac{1}{r}$, in the expression of the potential energy. A consistent transformation of the Schroedinger equation can however be carried out, and the method leads to an integral equation. This integral equation is solved completely and the analysis shows several points of interest.

6. Relation between the ψ function of the hydrogen problem and eigen-functions of the integral equation in the momentum space.

S. Bose, Dacca.

In the previous paper the integral equation in momentum co-ordinate which corresponds to the Schroedinger equation of state for the hydrogen atom has been solved. The relation of its eigen-functions with the known solution of the Schroedinger equation is discussed in this paper.

The differential equation of Schroedinger is transformed to a second integral equation in the ordinary space-co-ordinates as variables. For the sake of comparison, this equation is also deduced.

7. Width of the nuclear levels.

P. L. Kapur, Lahore.

An expression for the dependence of the partial width of a nuclear level on the energy and angular momentum of the ejected particle and as a matter for that of an incident particle as well is obtained. According to this formula the partial width for the case of thermal neutrons is 10^{-2}, 10^{-5}, 10^{-13} volts respectively for $s(l=0)$, $p(l=1)$ and $d(l=2)$ neutrons. This result agrees very well with the experimental values.

The final formula obtained is

$$\Gamma^l = \frac{(2l+1)\ (kr_0)^{2l+1}}{\{1+(kr_0)^{2l+1}\}} \cdot \frac{\hbar^2}{2Mr_0},$$

where r_0 is the nuclear radius and other symbols have their usual meaning.

Acoustics

8. Interferometric examination of light scattering in viscous liquids.

B. V. Raghavendra Rao, Bangalore.

Viscous liquids like glycerine, phenol and a few others were used for the study of the Doppler effect of light scattered by them. The investigation consists of the influence of temperature on the relative intensities of the central undisplaced component and the two Doppler components and on the state of polarization of the three components.

The acoustic velocity calculated from the Doppler shifts has been found to be very much higher than the corresponding ultrasonic velocity. With rise of temperature the Doppler components are found to approach the main undisplaced line with the result that this difference between the 'hypersonic' and 'ultrasonic' velocities goes on diminishing. This has been examined in detail and an explanation offered.

9. Determination of the acoustic velocities in liquids in the 'hypersonic' region.

B. V. RAGHAVENDRA RAO, Bangalore.

Hypersonic velocities have been determined in a number of liquids like acetic acid, formic acid, carbon disulphide, butyl alcohol and water and it has been found that in a few more liquids also one finds that the 'hypersonic' velocity is less than the 'ultrasonic' velocity, a result similar to that reported by the author in the case of acetone. The reason why in certain liquids the 'hypersonic' velocity is greater than the 'ultrasonic' velocity and also the reason for the reverse in certain other liquids has been examined.

General Physics and Heat

10. On the theory of frontogenesis.

S. K. BANERJI, Poona.

Petterson has shown that if S represents some conservative property of air, and if a quantity F is defined by

$$F = \frac{D\,|\,\nabla S\,|}{Dt},$$

where $|\,\nabla S\,|$ is the magnitude of the gradient of S, and $\frac{D}{Dt}$ denotes a differentiation following the motion of the air, then along a line of frontogenesis

$$F > 0, \quad \frac{\partial F}{\partial n} = 0, \quad \frac{\partial^2 F}{\partial n^2} < 0,$$

δn being normal to the line of frontogenesis. This quantity F can also be expressed in the form

$$F = -\,|\,\nabla S\,|\,\frac{\partial v}{\partial n},$$

where $\frac{\partial v}{\partial n}$ is the gradient of wind in the direction normal to the line of frontogenesis.

As shown by Silberstein, if δn_1 denotes the element of normal to the surfaces of equal pressure (p = const.), δn_2 to the surfaces of equal density (ρ = const.) and θ the angle between them, then the rate of increase of circulation in any circuit may be regarded as equivalent to the sum of the contributions

$$\frac{1}{\rho^2} \cdot \frac{\partial p}{\partial n_1} \cdot \frac{\partial \rho}{\partial n_2} \sin\theta,$$

per unit area of any surface bounded by the circuit. If S represents temperature of the air, then $-\,|\,\nabla S\,|$ is equivalent to $\frac{\partial \rho}{\partial n_2}$. That part of $\frac{1}{\rho}\,\frac{\partial p}{\partial n_1}$, which tends to produce motion can be taken to be equal to $v\,\frac{\partial v}{\partial n_1}$. As $\frac{\partial v}{\partial n_1}\sin\theta$ is proportional to the gradient of wind normal to the line of frontogenesis, we see that in a region in which the frontogenetical effect is maximum, the rate of increase of circulation is also maximum; and as the rate of increase of circulation is represented on a tephigram by $\int T d\phi$, we see also that along the line or region of frontogenesis, the stored up energy is also maximum.

11. Studies in thermal conduction of liquid helium II.

M. ZAKI UDDIN, Aligarh.

Two experiments for determination of thermal conduction in liquid helium II are described in this paper.

(1) The first method depends on using an alternating current and noting down the fluctuations in a suitable thermocouple fixed on a U-tube full of liquid helium II. This method was not found to be satisfactory.

(2) The second method consisted in using a combined vapour-pressure-thermometer and liquid helium manometer. This method was found to be very satisfactory. The following results were obtained with 2 capillaries, (1) 16·8 cm. long and 1·45 mm. in diameter, (2) 17 cm. long and 0·54 mm. in diameter. It was found that thermal conduction depends on:—

(1) Temperature gradient—for example, for the first capillary at 2·06°K. for $\Delta\ T = 5 \times 10^{-5}$ the value of thermal conduction was found to be $1 \cdot 1 \times 10^4$ cal./deg. cm. sec.
(2) Temperature of liquid helium—maximum value is attained at 1·91°K. for temperature gradient of $2 \cdot 90 \times 10^{-4}$ deg./cm.
(3) Diameter of capillary.

It was suggested that the study of viscosity of this strange 'super fluid' might lead to interesting results and it is gratifying to note that the dependence of thermal conduction on temperature gradient and diameter of the tube employed can be explained due to the peculiar physical properties of this liquid.

The value of thermal conduction in liquid helium is maximum round about 1·91°K.

12. Adsorption of dipole vapours on filter papers.

B. N. GHOSH, Patna.

The adsorption of water on filter paper either pure or impregnated with salts or metallic colloidal particles has been studied for a whole range of temperatures. The heats of adsorption thus obtained show rhythmic fluctuation with successive formation of adsorbed layers. These alternations of maxima and minima demand the existence of long range chemical forces of the exchange type besides the usual electrostatic and van der Waal forces. It is also suggested that the phenomenon of dissociation and association play a significant rôle in the adsorption of dipole vapour on amorphous surfaces, giving rise to an equilibrium of the type

$$(H_2O)_2 \rightleftarrows 2H_2O \rightleftarrows H^+ + OH^-.$$

There is also found an inherent instability in the formation of higher layers, giving rise to discontinuities at certain points of the isotherms. The phenomenon of activated adsorption is absent with pure filter paper and it seems that crystalline or colloidal impurities act like triggers in inducing this type of adsorption.

13. Methods of measuring yield value, viscosity and thixotropy.*

J. N. MUKHERJEE, N. C. SEN-GUPTA, *and* K. C. SEN, Calcutta.

The capillary and the rotary viscometers do not give the same Bingham Yield values and viscosities for bentonite suspensions. The yield value obtained by the capillary viscometer is about four to five times as great as that obtained by the rotary viscometer. A direct method using a rectangular flat cell (described in a separate note) for measuring the velocities at different depths in a flowing liquid has been developed which is expected to give yield value and viscosity in absolute units. The rotary viscometer gives values which are in better agreement with the velocity gradient method than those by the capillary viscometer. Variations in both the 'lower' yield value and the apparent viscosity of thixotropic suspensions with time have been observed. Lower yield values were measured by means of cylinders of different radii and also by a Stormer viscometer. Apparent viscosities were measured using the rotary viscometer. Compared with the apparent viscosity the lower yield value appears to give a better measure of the rate of thixotropic gelation.

14. A simple rotary viscometer for the study of anomalous viscous properties.*

J. N. MUKHERJEE *and* N. C. SEN-GUPTA, Calcutta.

For the study of anomalous viscous properties a simple viscometer which admits of rapid but reliable measurements is often needed. A rotary viscometer, in which the outer cylinder rotates and the torque on the inner cylinder is measured, has been described. It admits of easy end correction. There is no slip at the metal walls with sugar and glycerine solutions. Consistency curves of bentonite suspension, gelatin sol and starch paste representing respectively plastic, structure viscous and dilatant systems, have been obtained.

15. Measurement of velocity gradients for the study of viscous properties of non-Newtonian liquids.*

J. N. MUKHERJEE *and* N. C. SEN-GUPTA, Calcutta.

A method has been described which admits of a direct measurement of velocity gradients along the normal in a flowing liquid. The liquid is contained in a rectangular glass cell of depth of about 1 mm. fitted with stop cocks at both ends. The velocities of suspended fine particles of pure carbon have been measured at different depths with a microscope having an objective of fairly large working distance. Velocity distribution curves have been obtained with a sugar solution, two gelatin sols and a bentonite suspension. The sugar solution gives a perfect parabolic distribution of velocities characteristic of Newtonian liquids. Concentrated gelatin sols give curves of a higher degree than the parabola. The bentonite suspension shows a parabolic distribution of velocities with a central flat region. Viscosities and yield values calculated from this curve agree fairly well with those obtained by means of a rotary viscometer designed by the authors. Fuller details will be published elsewhere. A constant temperature arrangement and more accurate measurements of the low pressures involved are expected to increase the precision of results obtained by this method.

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* The work has been carried out under the scheme of research financed by the Burmah Oil Company (India Concessions), Ltd.

16. The change in the dielectric constant of liquids due to flow and the effect of a direct electric field on the same.

S. P. PRASAD, B. N. SINGH, *and* B. D. SINGH, Patna.

A change in the dielectric constant of liquids due to flow through narrow channels has already been reported by the present authors (*Science and Culture*, Vol. 7, p. 119, 1941). The present paper is an extension of the same study when a high direct electric field of the order of several kV/cm. is applied between the plates of the condenser through which the liquids flow. In case of liquids, xylene (a mixture of ortho, para and meta) and toluene, tried so far, it has been found that the change in their dielectric constant values produced due to flow, decreases in the presence of a direct electric field and greater the intensity of the field greater is the diminution. An attempt has been made by the authors to explain the results obtained by them by assuming the existence of oriented layers of molecules of the liquids both polar and non-polar, in the immediate neighbourhood of the walls of the experimental condenser. These molecules which are supposed to be more or less normal to the wall are bent sideways when the flow of liquids takes place and hence produce the decrease in their dielectric constant values. The thickness of the liquid layer which is thus influenced by the wall is of a very small order and, therefore, the change produced in the dielectric constant is also of an equally small order. The presence of a high direct electric field normal to the walls of the condensor will prevent the bending of molecules and thus would decrease the effect of flow.

17. Dielectric constants and polymorphism.

S. D. GOKHALE, Poona 2.

Dielectric constants of (*a*) resorcinol, (*b*) monochloracetic acid, and (*c*) ortho-nitro-phenol have been studied at various temperatures and at different frequencies.

Two polymorphic forms of resorcinol (cf. Robertson and Ubbelohde, *Proc. Roy. Soc.*, 1938, A, **167**, 1936), three of monochloracetic acid (cf. Pickering, *J.C.S.*, 1895, **67**, 674) and two of ortho-nitro-phenol have been observed. These forms are enantiotropic. The two polymorphic forms of ortho-nitro-phenol have been hitherto unrecorded.

The existence of these polymorphic forms is discussed in terms of the hydrogen bond.

18. State of solute in solution.

L. SIBAIYA, Bangalore.

Determinations of ultrasonic velocity in solutions using different solvents with but one solid solute have revealed that a unique value could be obtained by extrapolation for the acoustic velocity in the solute irrespective of the solvent employed. Nevertheless, it has been definitely established that this extrapolated velocity is not characteristic of the solute in the solid state, as computed from known values of elasticity and density. Observed velocity of sound in the molten state of the solute is shown in a few cases to be in fair agreement with the extrapolated values. It is therefore surmised that the state of the solute in solution at ordinary temperatures should almost correspond to the molten state of the solute at a temperature slightly higher than its melting-point. Other evidences in support of this conclusion are also given.

19. On the volume and surface resistivities of shellac moulded materials.

G. N. Bhattacharya, Ranchi.

The volume and surface resistivities of a number of shellac moulded discs of different compositions have been determined by the electron tube method using a Philips 4060 electrometer triode. Mercury electrodes were used and most of the determinations were made at a constant potential of 150 volts. The effects of humidity were studied over a wide range and the temperature variation of volume resistivity of a few discs has been recorded in the paper. The results have been presented in a tabular form as well as in a number of diagrams. It has been observed that at ordinary temperatures and 50% relative humidity the volume resistivity of shellac moulded discs of various compositions usually lies within $3{\cdot}5 \times 10^{13}$ and $2{\cdot}5 \times 10^{14}$ ohm/cm. Thus, shellac plastics may safely be classed among those materials which have a high value of volume or surface resistivity.

20. The effect of surrounding medium on the dielectric strength of shellac moulded materials.

G. N. Bhattacharya, Ranchi.

As the knowledge of the dielectric strength of insulating materials in different surrounding media is of utmost practical importance, a study was undertaken to find the effect of such media on the breakdown-voltage of shellac moulded materials. The electrodes used were a sphere and a flat plate made of brass and the rate of application of voltage was approximately 0·5 kV per second. The voltage was measured on the secondary side of the H.T. transformer by means of an accurate electrostatic voltmeter. The results of test with transformer oil, xylol, kerosene, turpentine and castor oil have been presented in the paper in a tabular form and among these turpentine gave the highest dielectric strength on short-time tests. The variation of the dielectric strength with the thickness of shellac-discs in different surrounding media has been shown in different curves.

21. On the variation of adiabatic compressibility with temperature.

M. Rama Rao, Bangalore.

The adiabatic compressibility of a liquid increases with temperature the increase becoming more rapid as the temperature increases. It is also known that compressibility in the gas phase is high and infinite at the critical point gas-liquid. It is found that the compressibility of a liquid at any temperature is dependent on how far the temperature is from the critical point. The variation of the adiabatic compressibility with temperature is given by the equation:—

$$\sqrt{\frac{V^{\frac{1}{3}}}{M\beta_{\phi}}} = C(\theta_c - \theta).$$

Where V, M, β_{ϕ} and C denote the molar volume, molecular weight, the adiabatic compressibility and a constant characteristic of a liquid independent of the temperature, respectively. θ_c and θ refer to the critical temperature and the temperature at which the compressibility is β_{ϕ}.

From dimensional analysis it is shown that $C\theta_c$ is given by

$$k\sqrt{\frac{\theta_c}{MV_c^{\frac{2}{3}}}}$$

thus leading to the equation:—

$$\sqrt{\frac{V^{\frac{1}{3}}}{M\beta_{\phi}}} = k\sqrt{\frac{\theta_c}{MV_c^{\frac{2}{3}}}}\left\{1 - \frac{\theta}{\theta_c}\right\}.$$

Here k has the same value for all liquids the value being equal to $1{\cdot}475 \times 10^5$.

22. Bose-Einstein condensation and thermal transpiration.

D. S. Kothari, Delhi.

The degeneracy in a Bose-Einstein gas is characterized by a fraction of the total number of particles in the assembly passing into a state of (almost) zero energy—the proportion of the non-energetic particles increasing as the temperature is lowered below the critical temperature at which degeneracy sets in. The pressure of the degenerate gas depends only on the temperature and is independent of the volume. In the discussion of thermal transpiration for a Bose-Einstein gas two cases have to be considered: (1) Gas is non-degenerate in both chambers, and (2) gas is non-degenerate in the high-temperature chamber and degenerate in the other one. The case when the gas is degenerate in both chambers does not exist.

Kennard drew attention some time ago that in a reversible process which is unavoidably accompanied by an irreversible process, the change in the entropy of the universe *due to the reversible process* does not vanish, but the entropy decreases. As examples of such reversible processes Kennard considered thermal transpiration for a *classical* gas and Thomson effect. Kennard's discussion is here extended to a Bose-Einstein gas. The results involve the duration of the reversible process; and how a lower limit can be assigned to the time taken by a reversible process is examined.

The effect of a uniform field of force on the (degeneracy) critical temperature is considered.

23. Flow of energy in thermal transpiration for a Bose-Einstein and a Fermi-Dirac gas.

D. V. Gogate, Baroda *and* D. S. Kothari, Delhi.

In the case of two chambers, maintained at different temperatures, containing an *ideal* gas (classical $\beta = 0$, Fermi-Dirac $\beta = -1$, or Bose-Einstein $\beta = +1$) and intercommunicating through an effusion-orifice, there is, in the steady state brought about by thermal transpiration, no net flow of matter but a continuous flow of energy (due to effusion of particles) from the chamber at the higher temperature to the other one. This energy flow is determined for a completely relativistic and a completely non-relativistic gas. Three possible cases are discussed for each of them: (*a*) gas non-degenerate in both chambers, (*b*) gas degenerate in both chambers, and (*c*) gas non-degenerate in one chamber and degenerate in the other. Case (*b*) is possible for a Fermi-Dirac gas only.

In case (*c*) the rate of flow of energy to a first order is the same as in case (*a*) but with the temperature of the chamber at the lower temperature (i.e. the chamber containing the degenerate gas) put equal to zero, which is in accord with the properties of a degenerate gas.

In case (*a*) for a relativistic classical gas ($\beta = 0$), the energy flow is proportional to the concentration which is the same in both the chambers and to the difference of temperature between them. For a non-relativistic *classical* gas, the energy flow varies as $n_1 T_1^{\frac{1}{2}} (T_1 - T_2)$, n_1 being the concentration in the chamber at T_1. For a Fermi-Dirac gas the flow is slightly less and for a Bose-Einstein gas slightly greater than that for the classical gas under the same conditions.

In case (*b*) when there is Fermi-Dirac degenerate gas in the two chambers, the energy flow to a first approximation, both for the relativistic and non-relativistic cases, varies as $n_1^{\frac{1}{3}} (T_1^2 - T_2^2)$; in the relativistic case, of course, $n_1 = n_2$. For fixed temperatures, the energy flow is always greater when the concentrations are such that the gas in the two chambers is degenerate than when the gas in both of them is non-degenerate.

24. Thermal transpiration and reversible process for a degenerate gas.

D. V. GOGATE, Baroda.

Kennard has shown that the basic theorem of thermodynamics that 'the entropy change of the universe during a reversible process is zero' loses its validity if we do not take account of the irreversible flow of heat due to conduction which necessarily accompanies a reversible process. He has discussed thermal transpiration for a classical perfect gas and has made evident the necessity of a restriction upon the general theorem of entropy change. The discussion of Kennard is extended to the case of a degenerate gas and it is shown how the general theorem fails in this case also if the restriction imposed by Kennard is ignored.

25. The normal velocity distribution of the electrons emitted from oxide-coated emitters, with platinum and carbon as base metals.

B. N. GHOSH, Patna.

From a survey of the earlier work on the velocity distribution of the thermionically emitted electrons it appears that for pure metallic emitters the out-going electrons have a Maxwellian distribution of velocity with a characteristic temperature which is equal to that of the emitter. The author has made a detailed survey of the velocity distribution of the electrons coming out from pure and composite emitters, and finds a general confirmation of the report published by the earlier worker in this field as far as emission from pure metals are concerned. But in the case of composite surfaces the results obtained are at complete variance with those available in the literature of the subject. Here three groups of electrons have been traced by a study of the curve obtained by the well-known retarding field method. The temperature of two groups are higher than that of the emitter and of one group lower than that of the latter. But as the temperature of the emitter is progressively lowered the temperature of the three groups seem to approach each other and at a particular temperature called 'Convergence Temperature' they seem to fuse into one. This characteristic temperature of the electrons is equal to that of the emitter at that point. Attempts have been made to get the field-distance and potential-distance curve of the emitter by Nottingham's Photo-electric method as well as from an evaluation of the variation of the thermionic work-function with different applied voltage. The curve with a single hill and a plateau thus obtained do not agree with the theoretically calculated curve of the author (to be published later) where the presence of multiple hills is assumed for the explanation of the enhanced temperature of the two groups of electrons. These higher values are therein explained as a tunnel effect through the initial potential hill of the base metal by a resonance effect. The values of contact potential difference between Pt or C (pure and oxide-coated) against W and Ni have been measured by proper displacement of curve.

26. Effect of pressure and temperature on the rate of water-filtration from clay suspensions.

N. C. SEN-GUPTA *and* M. M. DEY, Khodaung (Burma).

Filtration characteristics of stable clay suspensions were studied at temperatures between 30°C. and 80°C. and at pressures between 100 and 1,000 lb. per sq. in. The cumulative volume of filtrate at any constant temperature and pressure increased proportionally with the square root of time of filtration. The cumulative filtrate volume V (per sq. cm. of filter bed) varied with the pressure P, according to the relation $V = kP^x$, where k is a constant and the value of x was found to be 0·19 for the particular mud used. The permeability K of the cake formed on the filter paper also decreased with increase in pressure.

Values for V at a given pressure increased with temperature and the product $V \cdot \eta^{0 \cdot 5}$ also rose slowly with temperature. This may be due to incipient coagulation of the colloid fraction of the mud which might be expected at elevated temperatures. This coagulation increased the permeability of the filter cake. It was observed that the product $V \cdot (\eta/K \cdot P)^{0 \cdot 5}$ is a constant for the mud used independent of temperature and pressure. Whether this product is constant for all types of muds or not is now being determined.

27. Application of relativity to the kinetic theory of gases.

BRAJABIHARI PATTANAIK, Cuttack.

The classical equation connecting the pressure, the volume, and the temperature of a perfect gas is $pV = RT$. In the present paper it has been shown that by applying the principles of relativity the equation assumes the form $pV = RT(1-a_1T-a_2T^2-\ldots\ldots)$, where a_1, a_2, etc., are constants.

Magnetism

28. The magnetic susceptibility of the water of crystallization.

H. S. VENKATARAMIAH, Bangalore.

The molecular diamagnetic susceptibility of the water of crystallization has been calculated for a number of diamagnetic crystals by making use of the values of the susceptibility of the hydrated and the anhydrous forms of the same substance. The water of crystallization is found in most cases to be considerably less diamagnetic than free water and this effect appears to be associated with the low vapour tension of the water in such crystals. For a substance with a high acqueous tension like $Na_2CO_3 \cdot 10H_2O$ the water in the crystal is slightly more diamagnetic than free water.

29. Influence of the 'hydrogen bond' on diamagnetic susceptibility.

H. S. VENKATARAMIAH, Bangalore.

The magnetic susceptibilities of solutions of alcohols in carbon tetrachloride and of chloroform in ether have been measured by employing a Curie balance. The diamagnetic susceptibility of the alcohol solutions is found to be higher than the value calculated according to the additivity law. The increase in susceptibility is traced to the breaking up in solution of the hydrogen bonds between alcohol molecules which exist as polymers in the pure liquid. Hence the formation of a hydrogen bond diminishes the diamagnetic susceptibility and this effect is shown to be due to the proton of the hydrogen attracting the oxygen ions of the associated molecules closer and thus diminishing their effective radius and consequently diminishing their individual contributions to diamagnetic susceptibility. In the case of ether-chloroform mixture the observed susceptibility is slightly less than the calculated susceptibility and this effect is ascribed to the formation of an intermolecular bond through hydrogen between the chloroform and the ether molecules.

30. A magnetic study of acetic acid and acetates in aqueous solutions.

K. N. MATHUR, N. K. MUNDLE, *and* S N. SINGH, Lucknow.

The state of acetic acid when dissolved in water still continues to be a controversial matter. From measurements of magnetic susceptibilities Sibaiya and Venkataramiah found that Pascal's addivity law holds good up to 50% concentration, but a deviation occurred above this concentration. This was explained to be due to the formation of hydrates. According to Krishnamurty, acetic acid forms hydrates at 75% and lower concentrations, but Koteswaram on the other hand from observations on Raman effect concludes that no hydrate is formed but the acid breaks up into lower polymers with increasing dilution. Magnetic measurements have also been made by S. R. Rao and Narayanswamy and by one of the authors.

In view of the physico-chemical evidence that acetic acid is highly polymerized in the pure form it was considered desirable to study also the magnetic susceptibilities of solutions of a number of acetates and the variation with concentration. Besides acetic acid, the acetates of ammonium sodium and lead have been studied over a range of concentrations. A modified form of Decker's balance was used and care was taken to maintain a constant temperature. The nature of concentration susceptibility curves obtained and their bearing on the nature of the solutes have been discussed.

Meteorology

31. Effect of meteorological conditions on the electrical conductivity of air at Colaba (Bombay).

S. M. MUKHERJEE, Bombay.

Data of electrical conductivity of the air at Colaba measured with a Gerdien apparatus during 1935-36 are correlated with the meteorological conditions prevailing at the time of observation. It is found that conductivity is much more dependent on wind direction during the dry months, November to April, than during the period May to October. This is explained as being due to the difference in the nature and concentration of pollution such as smoke, dust and products of combustion from the commercial and industrial parts of the city during the former period and sea spray and salt nuclei in the latter. When dust is raised in the air by wind, it increases the conductivity, the value being greater at a height of about 50 feet above ground than near the ground. Improvement of visibility goes hand in hand with an increase of conductivity and vice versa. During rain negative conductivity increases rapidly with intensity of rainfall but positive conductivity remains practically steady and somewhat below its normal value. The conductivity is greater after than during rain. The best time of the day for regular daily observations of air conductivity at Colaba is discussed.

32. Seismological features of the Satpura earthquake of the 14th March, 1938.

S. M. Mukherjee, Bombay.

An earthquake of moderate strength occurred in the early morning of March 14, 1938, in the Satpura range. Compared to its magnitude the shock was felt over an unusually large area of about 400,000 sq. miles. It is estimated that a maximum surface intensity between VII and VIII in the modified Mercalli scale of 1931 was reached near the epicentre. The isoseismals due to this earthquake are found to be roughly elliptical with the long axis in an approximately north-south direction. It is probable that the earthquake was connected with a fault line in the Satpuras. From the seismological data of near stations, the position of the epicentre is calculated as 21° 32′ N. and 75° 50′ E. and the time of origin as $0^h\ 48^m\ 30^s$ G.M.T. The depth of focus is calculated as 40 Km. These determinations are supported by macroseismic data and observations of P, P′ and P^P at distant stations. The magnitude of the shock was about 5·5 and energy about 10^{19} ergs. Velocities of the various crustal waves which are identifiable in the Indian seismograms, are given. Thickness of the granitic layer (including the sedimentary one) is tentatively calculated as 40 Km. and that of the basaltic one as 10 Km. These values agree with those observed for the Eastern Alps region. The shock apparently originated near the bottom of the granitic layer. Some of the seismograms of this shock recorded at the Indian stations are reproduced.

33. Rainfall frequency at Patiala.

L. D. Mahajan, Patiala.

The frequencies of rainfall at Patiala which lies in the south of the Punjab has been studied. They have been broken up into a number of classes and each class except the first is a simple multiple of 0·25″ as its medium value. But the first class with a range of 0·01″ to 0·12″ has its medium value 0·06″. The data extend from 1900 A.D to 1940 A.D.

The study of the frequencies shows that the light showers having the mean value 0·06″ are less common than the showers of mean value 0·25″ or thereabouts. The heavier showers are most probably due to its proximity to the Sivalik Hills which extend from its south-east to its north-east.

The greatest amount of rainfall at Patiala is contributed by falls of about 0·25″ medium value, and next to it by falls of about 0·50″ medium value. The average heaviness of the rainfall is 0·59″. Thus the greatest quantity of rainfall is yielded by falls not differing very much from those of average heaviness which confirms Blandford's statement. Besides there is marked diminution in the number of falls of the lowest value class during the last four decades and the frequency of rainfall is decreasing irregularly with time.

34. Measurement of total precipitable water in the atmosphere above Poona by a spectroscopic method.

K. L. Gadre, Poona.

Regular estimations of the total precipitable water, W, in the atmosphere above Poona have been carried out with the help of absorption measurements at the ρ ($0{\cdot}93\mu$) band of water vapour. The measurements were made with a glass prism spectrograph, a sensitive thermopile and a Moll galvanometer, sunlight being reflected by the front silvered mirror of a heliostat and focussed on the slit of the spectrograph. The diurnal and seasonal variations of W are discussed. The values of W obtained by the spectroscopic method are compared with those from the records of sounding balloons and the observations of heat radiation from the night sky. The spectroscopic estimations are found to be lower. The onset of sea-breeze and thunder-showers during some occasions in April to June this year, and the S.W. monsoon are found to be indicated earlier by the increasing tendency of W.

Oscillations and Waves

35. Thermionic emission from the filament of a triode maintained by its space current.

R. L. Narasimhaiya, Bangalore.

In an earlier paper (*Proc. I.R.E.*, **23**, 249, 1935) the author has shown that certain types of dull emitter triodes can maintain electron emission from their filaments even with their low tension supply disconnected provided the electrode currents through the tubes are sufficiently high. In a later note, Pandya and Pathak (*I.J.P.*, XIII, VI, 409, 1939) state that the emission is maintained probably by the inductive effect of the chokes used, basing this conclusion on their observation that while D.C. eliminators are capable of maintaining this emission, a battery of cells is not. It is shown in this paper that this observation is incorrect and that the electrode currents are responsible for the continuance of electron emission.

36. The photo-diminution of conductivity in chlorine subjected to electrical discharge.

S. S. Joshi *and* P. G. Deo, Benares.

Earlier results (Joshi and Narasimhan, *Curr. Sci.*, 1940, **9**, 535) in this line have disclosed the existence of a new type of photo-electric effect in a gas (chlorine) subjected to electrical discharge. The discharge current diminishes immediately on irradiation. It is found that this suppression of current increases markedly from red to violet. Data are obtained to correlate in detail the magnitude of this effect as a function of the intensity and frequency (especially in relation to the absorption spectrum of chlorine) of radiation employed.

The (emission) spectrum of chlorine subjected to discharge under conditions, where this photo-effect is maximum, is found to consist almost entirely of *faint* bands, despite several hours of exposure with the then available instrument, viz., a Hilgher's constant deviation spectrograph.

Work is in progress to investigate if a spectral shift in respect of wave-length or (and) the intensity distribution in the chlorine spectrum is produced due to irradiation under conditions of maximum photo-effect under a wide range of conditions.

37. Effect of early morning sunrise on the E-layer.

H. B. Mohanty, Cuttack.

It is not yet definitely known whether the free electrons, present in the E-region of the ionosphere, disappear by attachment to neutral atoms forming negative ions or by recombination with positive ions forming neutral particles. Information in this respect, however, can be obtained by observing the effect of the first rays of the sun when they strike the layer. Due to the removal of the u.v. rays by absorption in passing through the ionized regions and the ozone layer the visible rays of the sun are the first that reach the E-layer directly above the point of observation. So if attachment be the main dissipative process for electrons in the E-region, the consequent presence of a large number of negative ions will give rise to an instantaneous increase in ionization due to photo-detachment of electrons by the visible rays of the sun while in the case of recombination as there will be only neutral atoms present in the E-layer no such increase will take place until the time of ground sunrise when the u.v. rays will directly impinge upon the layer. Depending on the latitude of the place and the season of the year, sunrise takes place on the E-layer several hours before the ground-sunrise at the place of observation. Continuous photographic records taken of the reflection of radio wave pulses from the E-layer at night over a period of several months showed that long before the ground-sunrise the reflection coefficient of the layer showed instantaneous increase, as soon as the first visible rays of the sun strike the layer. This shows the presence of a large number of negative ions indicating thereby attachment to the main dissipative process operative in the E-layer. It has been shown also from theoretical considerations that the free electrons in the ionosphere disappear by attachment rather than by recombination.

38. A light effect in gases under electric discharge.

S. S. Joshi *and* G. S. Deshmukh, Benares.

The observation reported (Joshi and Narasimhan, *Curr. Sci.*, 1940, **9**, 535) previously viz., an instantaneous diminution on irradiation, of the discharge current in chlorine has now been extended to other gases, subjected to ionization by collision in electric fields due to alternating potentials in Siemens' tubes. The experimental arrangement is essentially the same as before; the current, however, is determined simultaneously by two methods, viz., by an A.C. indicator of the rectifier type and a reflection galvanometer actuated by a vacuo-junction in the discharge circuit.

It is observed that the photo-diminution of the discharge current varies rapidly in the order, chlorine > bromine, hydrochloric acid gas > iodine. In fact, observation of the effect in iodine is nearly impossible without a sensitive indicator and adequate irradiation. Furthermore, especially in the case of iodine the photo-effect is easily masked by a dark, in part, '*ageing*' effect, i.e. a time-variation of the discharge current produced under a constant applied potential; this varies in the order, iodine > bromine > chlorine. Other conditions remaining the same, over a limited range, a rise in the gas pressure and temperature tends to diminish the light-effect; an increase in the applied potential, frequency of the A.C. supply and of the external radiation employed, as also its intensity, increases it.

Preliminary experiments have shown that differences in the magnitude of the light effect in chlorine using plane polarized and equally intense ordinary light lie within the margin of probable experimental error.

The use of larger discharge tubes, much greater intensity of and more short-wave radiation, and of specially sensitive current indicators has revealed the effect in oxygen > air nitrogen > hydrogen; its magnitude is, however, very considerably smaller with these gases than in the case of halogens. The gas pressures employed in these later experiments were varied in the range 1·5 to 2 cm. of Hg. Subsequent work has revealed that with any given gas, its pressure is an important determinant of magnitude of the '*light effect*' produced under a certain range of applied potentials. Not only the magnitude but even the sense of the photo-effect is liable to change, if the operating conditions are altered. Despite the use of very much greater intensity of light than above and more sensitive arrangement for current detection, neon, mercury and sodium vapour have *so far* failed to show any effect within the limitations of the available apparatus. Further work with yet more refined technique is in progress with a view to investigate the generality of the effect.

39. Plasma electron oscillation and its effect on the measurement of dielectric constant of ionized gas in a discharge tube.

S. R. Khastgir *and* Md. Emran, Dacca.

Measurements of the effective dielectric constant of ionized air, over a wide range, from very low to very high radio-frequencies have shown some anomalous features. The experiments with a discharge tube carried out in the ultra-high frequency range for a small value of the discharge current showed that for wavelengths smaller than about 9 metres the effective dielectric constant of the ionized air was definitely less than unity. Starting from very small wavelengths, it was found that the effective dielectric constant of the ionized air steadily decreased up to a certain wavelength, beyond which it increased gradually approaching the value of unity in the neighbourhood of 9 metres. Similar measurements at medium radio-frequencies showed that the effective dielectric constant of ionized air in a discharge tube was definitely *greater* than unity and the value slowly diminished, as the frequency of the measuring field was diminished.

These results suggested the possibility of a resonance frequency or frequencies in the region of very high radio-frequencies. To examine this possibility, experiments were performed with the same discharge tube as had been used for the dielectric constant measurements. There was definite experimental evidence of electronic oscillations in the discharge tube exactly in the region of the observed anomalous variation of the dielectric constant of the ionized air. The experimental results could be explained accordingly with the help of Lorentz's dispersion formula.

Raman Effect

40. Raman spectrum of liquid PCl_5.

Bishambhar Dayal Saksena, Cawnpore.

Assuming the triangular bi-pyramid structure for liquid PCl_5 molecule as suggested by Mourou, Magat, and Wetroff (*Proc. Ind. Acad. Sc.*, A, 1938, **8**, 357) the force constants of P-Cl and Cl-Cl valence are calculated and compared with the values found in other compounds. It is found, that without using the intra-valence force constants, whose value is generally very low, the value of the P-Cl force constants, which is found as $3{\cdot}667 \times 10^5$ dynes is greater than that in PCl_3 although the P-Cl distance in PCl_5 is greater than that in PCl_3. The value of Cl-Cl force constant is negative although it is positive in other chlorine compounds like the tetra-chlorides. These considerations, and the fact that the dipole moment is positive are not in favour of this structure.

The square pyramid model, in which the phosphorus atom is at the centre of a square having four chlorine atoms at the corners and the fifth chlorin atom outside the square, is next considered. The twelve internal frequencies for this model are then calculated, on group-theory methods, by assuming the three force constants of P-Cl valence $= 1{\cdot}53 \times 10^5$, of directed valence $\cdot 01 \times 10^5$, and of Cl-Cl repulsion $= \cdot 2 \times 10^5$ dynes.

Class.	Calculated frequencies.	Observed frequencies.
A	410, 311, 122	392, ? , 100 in liquid 393, 351, 96, in soln. in PCl_3.
B	No frequency.	
C	279, 70	271 in liquid.
D	146	
E (doubly de-generate).	497, 152, 116	449, 495, 190

The agreement of frequencies is fairly close, and the force constants are of the right order to justify the proposed structure which has a positive moment.

41. Interpretation of the polarized lines in the Raman spectrum of molten naphthalene.

BISHAMBHAR DAYAL SAKSENA, Cawnpore.

The molecule of naphthalene contains 18 atoms and possesses 48 vibration frequencies. The symmetry of the molecules belongs to the point-group D_{2h}. From the character—table pertaining to this group, it has been possible to write down the symmetry co-ordinates for all the 48 frequencies.

Nine polarized Raman lines, two very strong 3054, 1379, four strong 1460, 1024, 760, 511, one weak 942, and two very weak 772 and 1328 are known from author's polarization studies (*Proc. Ind. Acad. Sc.*, A, 1938, **8**, 73). 1379 and 3054 represent, mainly, the radial oscillations of carbon and hydrogen atoms respectively towards or away from the C.G.; 760 and 1460 are the transverse oscillations of the four carbon and four hydrogen atoms respectively which are near the C.G. of the molecule; 511, 1024 represent similar oscillations of those four carbon and four hydrogen atoms respectively which are further from the C.G.; 942 represents a radical oscillation of two carbon atoms towards and of four six carbon atoms away from the C.G. at the sametime; 772 represents a radial oscillation of four nearer carbon atoms moving towards and of four further carbon atoms moving away from the C.G. at the same time; 1328 represents a similar oscillation of the hydrogen atoms.

42. Raman spectra of iodic acid solutions.

J. R. SARAF, Lucknow.

Nayar and co-workers have reported breaks in the curves of the physico-chemical properties of iodic acid solutions. Such breaks occur at 0·04 N. and 0·1 N., which they interpret as transition points in the polymerization of (HIO_3) molecules.

Raman effect would perhaps be the ideal subject which would afford evidence in support of the above interpretation. Solutions were therefore prepared of concentrations ranging on either side of the transition points, viz. 0·03 N., 0·07 N. and 0·2 N. and also of a more concentrated solution 4·5 N.

The concentrated solution gives three bands of which the most intense and broadest one, when microphotometrically examined, is found to consist of three sharp components of $\Delta\nu$ 776, 804 and 825 in the order of decreasing intensity. The second band at 649 consists of only one component, while the third band consists of two components 333 and 377, and 333 shows signs of further splitting. 0·2 N. and 0·07 N. each gives only one line at 806 (the line is being microphotometrically examined).

A 0·03 N. solution of the acid gives a line at 812 and with a 0·2 N. KIO_3 solution the same frequency shift is obtained, suggesting thereby that the former frequency is due to IO_3 ion. Other lines have been interpreted on the theory of polymerization or co-ordination.

43. Raman effect in immiscible liquid systems.

R. SREE *and* L. SIBAIYA, Bangalore.

The light scattered from two immiscible liquids one lying on top of the other in a Wood's tube with the interface halfway up the tube window has been examined spectroscopically. Using the carbondisulphide-methyl alcohol pair the Raman lines of carbondisulphide are observed to extend into the methyl alcohol region while the alcohol lines do not penetrate into the carbondisulphide. This result finds an explanation in the known solubilities of the two liquids in each other. In the case of water and carbontetrachloride the liquids are highly immiscible as the Raman lines and bands of one liquid do not perceptibly run into the region of the other. The light scattered from water-carbondisulphide pair behaves likewise. But when this system is allowed to stand by for some days, the light scattered from the interface reveals the strong Raman line of sulphur at 470 cm.$^{-1}$ excited by λ 5461Å. It therefore seems likely that sulphur either dissociated from or dissolved in carbondisulphide prefers to accumulate at the interface. Interfacial scattering from other binary liquid systems has been studied.

Spectroscopy

44. Swan band characteristics in various flames.

N. R. TAWDE *and* J. M. PATEL, Bombay.

Johnson and Tawde (*Proc. Roy. Soc.*, A, **137**, 575, 1932) had noticed that the vibrational transitions of the C_2 Swan system in the oxy-coal gas and Bunsen flames come out with different intensities in spite of the Condon distribution remaining the same. In this paper we have investigated the gross intensity distribution of Swan band system excited in different types of flame sources—Meker burner (under two different conditions), jet burner (under two conditions), Primus stove flame and Bunsen burner. The results have been compared. This is an extension of the work on flames previously reported (*Bom. U. Jour.*, **6**, ii, 29, 1937).

45. On the absorption spectra of alkaloids, such as codeine, heroine and morphine and the possibility of detection of alkaloids in general in the saliva and sweat of drugged horses.

S. DATTA *and* G. KARMAKAR, Rajshahi.

It is well-known that the alkaloids exhibit very characteristic absorption curves even when they are present in minute traces and the nature of the curves and the position of the peaks of maximum absorption enable them to be easily distinguished from one another. The absorption spectrum of only a few alkaloids are, however, published and of the common varieties of poisonous alkaloids, which in very small quantities have a deleterious effect on the drugged animal, only those of caffeine, cocaine, quinine and strychnine are known. As besides these, codeine, heroine and morphine are also not rarely used for drugging purposes, the characteristic absorptions of these substances as also of caffeine, cocaine, quinine and strychnine at various large dilutions were first studied with a Spekker photometer and an atlas of absorption spectra of these substances as prepared.

The second part of the experiment consisted in the identification of small traces of alkaloids which are liable to be excreted in the saliva and sweat of horses drugged with these alkaloids. As their absorptions are complicated by the presence of impurities such as protein, mucin, organic salts, etc., an attempt was first made to remove these impurities by chemical and centrifugal methods. The results, however, were not satisfactory. It was therefore decided to separate the alkaloids from solutions of saliva and sweat by standard chemical methods and finally dissolve them in dilute hydrochloric acid and subject the acid solution to spectrophotometric examination.

The results so far achieved indicate that whenever the animal is drugged with not too small quantities of these alkaloids (in the case of caffeine the limiting dose is 1 dr.) the salivary secretions do contain sufficient quantities of these drugs which can be identified by the spectrophotometric method. The sweat of the horses, however, did not show any characteristic absorption of the alkaloids.

46. Intensity variations observed in the spectra of hydrogen.

R. K. Asundi, Nand Lal Singh, *and* Jagdeo Singh, Benares.

Two Geissler discharge tubes, one of the Guild form containing only pure hydrogen and another of H type containing hydrogen, helium, mercury and a trace of carbon have been used. The spectra obtained on excitation by a high frequency discharge (range of available wavelengths being 255 to 485 metres) and by a small induction coil (hammer break type giving 1 cm. spark) have been photographed in the visible region using a constant deviation glass spectrograph. We wish to record the following observations:—

(1) The coil discharge in the Guild form tube shows that the H_α and H_β lines are more prominently developed than the secondary spectrum in the visible region, while the h.f. discharge shows just the opposite distribution of intensity.

(2) In the h.f. discharge in the H type tube the secondary spectrum does not stand out clearly owing to the overlap of CO bands, mercury and helium lines. But the behaviour of H_α and H_β lines is interesting. The intensity of these lines undergoes a change with frequency of the discharge (using external electrodes). The intensity of other lines due to various emitters does not appear to suffer any noticeable change with frequency within the range here used. For example the plates show that at wavelengths of 320 and 480 metres H_α line is weaker than the helium λ6678 line while at wave-lengths of 340 and 465 metres the H_α line is the stronger of the two, these being the four wave-lengths of the oscillations for which the spectrum was photographed.

47. Spectroscopic investigation of high frequency discharge.

R. K. Asundi, Nand Lal Singh, *and* Devi Datt Pant, Benares.

High frequency oscillations were obtained by a suitable valve circuit, the range of wave-lengths available being 255 to 485 metres. The discharge took place in a glass tube (length 87 cm. and inner diam. 2·4 cm.) with a glass window sealed on to one of its ends and a quartz window to the other. Two rings of thin metal sheet served as external electrodes which could be moved along the length of the tube. The spectra excited at different pressures of air have been photographed. A small quartz spectrograph and a constant deviation glass spectrograph were used to get simultaneous spectra in the ultraviolet and the visible regions. No particular precaution was taken either to dry the air or clean the tube free from carbon and mercury. We distinguish between a predominantly pink discharge which obtains when the distance between the electrodes is greater than that for which the discharge is either predominantly violet-blue at high and medium pressures of air (12 mm. and 8 mm. respectively as measured by a manometer) or predominantly greenish-grey at low pressures (6 mm.). The discharge was maintained with oscillations of length about 372 metres for which the glow was visually the brightest.

The main results obtained so far are:—

(1) The pink discharge at medium pressures consists mainly of 1st positive and 2nd positive bands of nitrogen (N_2) and the (0, 0) and (1, 0) bands of OH. It also shows the main lines of the arc spectrum of mercury, and the gamma bands of NO.

(2) In the pink discharge at high pressures the mercury lines are greatly inhibited, only the $\lambda 2536$ line being registered with low intensity.

(3) The violet-blue discharge obtaining at medium pressures shows mainly the Angstrom bands (CO), negative bands of nitrogen (N_2^+), the two OH bands, the gamma bands of NO, a few first negative carbon bands (CO^+) and a number of arc and spark lines of mercury.

(4) The greenish-grey discharge which obtains at low pressures shows the arc and spark lines of mercury, the two OH bands and some of the negative bands of nitrogen (N_2^+) but in addition gives intense Angstrom bands and a strong development of the first negative bands of carbon of which a few are probably new. It is remarkable that there is no trace of 3rd positive carbon or associated bands and of the 4th positive carbon system only a few are present with low intensity.

Technical Physics

48. Application of the photoelectric cell to the study of light-flashes.

Y. V. Kathavate *and* D. V. Gogate, Baroda.

The object of this paper is to describe some experiments illustrating the application of the photoelectric cell to the determination of the quantity of light in discharges of short duration. Two complementary methods, viz. (i) the light-flash method, and (ii) the dark-flash method are described and the results are used in estimating the amounts of light in the light-flashes given out by different quantities of magnesium powder. The relation between the quantity of light in the flashes and the quantity of magnesium powder burnt comes out to be almost linear except for very small quantities of the powder. The method is also used for the calibration of the speeds of camera shutters.

49. The optical hygrometer and its working.

L. D. Mahajan, Patiala.

The optical hygrometer, which had recently been constructed (*Proc. Ind. Sc. Cong.*, 1941) in this laboratory, has been improved in construction. Its working and theory have been studied in detail. The rotation of the balancing rod which is measured by the lamp and scale arrangement is proportional to the change in humidity and is calculated by the formula: $\frac{H_1-H_0}{H_2-H_0}=\frac{x_1}{x_2}$, wherein H_0 is the initial relative humidity of the air and H_1 and H_2 are the relative humidities recorded after some time and X_1 and X_2 are the corresponding shifts of the spot of light on the scale.

Its sensitiveness has also been studied which shows that it is many times more sensitive than the other kinds of hygrometers. A few observations recorded with this instrument are compared with those of the others and they confirm its theory, working and use.

X-rays and Crystal Structure

50. X-ray studies in Indian coals, Part I.

J. DHAR *and* B. B. NIYOGI, Dhanbad.

Several samples of vitrains and of a few other constituents of coal have been studied by the X-ray diffraction method. The vitrains so far examined indicate the presence of two characteristic rings of spacings 3·7-3·8A° and 2·1-2·3A°. These spacings are analogous to the spacings 3·4A° and 2·1A° characteristic of graphite. The spacing 3·7-3·8A° refers to the inter-layer distance between hexagonal networks of carbon and is in accordance with the fact that the minimum distance of approach between carbon atoms in adjacent organic molecules lies between 3·4-3·9A°. All the diffraction pictures show a strong scattering at a small angle corresponding to a spacing of nearly 12·3A° which is probably due to the presence of a carbon complex of large molecular units.

The diffraction pictures of vitrain, durain and fusain are distinctive among themselves. The durain picture is a superposition of the pictures of graphite and ash. The characteristic diffraction rings of Raniganj series vitrains are distinctly broader and more diffuse than those of the same from the Jharia coalfield. In general the interspaces between rings in pictures of the Barakar series vitrains of the Jharia field are much clearer than those of the Raniganj series. The Raniganj series vitrains contain many other sharp but weak rings. These suggest a difference in rank and quality between vitrains from the Raniganj and Barakar series. This is in keeping with the findings from chemical analysis.

51. Extra spots in the Laue photographs.

K. BANERJEE, Dacca.

An intensive series of measurements have been carried out on the extra reflections in the Laue photographs observed by Friedrich, Zachariessen, Preston, Raman and others. In recent years Faxen, Zachariessen, Bragg and Raman have in different ways attempted to explain the effect.

An accurate determination of the scattering angles for the extra spots have been possible by the help of a cylindrical camera of 17·32 cm. diameter which has been constructed in such a way that its axis is accurately along the path of the narrow X-ray pencil. Extra reflections from the 211 (cleavage plane) of calcite were measured by M. Ganguly and R. K. Sen at the author's laboratory. The crystal was adjusted on the camera with the cleavage face on the axis of rotation. X-ray beam from a copper anticathode passed through the long narrow slit and fell on the crystal which could be set at different angles by the help of a graduated circle. The positions of the Laue spot, the extra spot and the direct pencil were measured by means of a travelling microscope. It has been found that $\theta+\phi=2\theta_B$ within 2′ even for such wide variation as $\theta\sim\theta_B=2^{\circ}\cdot5$, where θ and ϕ are the glancing angles of incidence and reflection and θ_B is the Bragg angle. This has also been verified by the coincidence methods in which extra reflections at nearly Bragg setting and at a setting for which $\theta-\theta_B$ was about 2°·5 illuminated the upper and the lower half of the same photographic film by the help of a suitable stop. This contradicts both the formulae of Faxen and Zachariessen as either requires a shift of about 24′ between $\theta+\phi$ and $2\theta_B$.

Half intensity widths of a number of extra spots in the Laue photographs of metadinitrobenzene have been measured by the help of a Zeiss microphotometer at a number of settings and have been found to be independent of the glancing angle of incidence. The spots are found to be much sharper than as required by Zachariessen's theory.

SECTION OF CHEMISTRY

President:—M. Qureshi, M.Sc., Ph.D., F.N.I.

General and Inorganic Chemistry

1. Complex compounds of metaphenylene dibiguanide with metallic elements. Copper metaphenylene dibiguanidine and its salts.

Priyadaranjan Rây *and* Sushil Kumar Siddhanta, Calcutta.

In course of our investigation on the complex compounds of biguanide and its substitution products with metallic elements, we have found in *m*-phenylene dibiguanide a quadridentate molecule which can co-ordinate with a central atom like copper and nickel with four points of attachment. In the present paper a number of copper *m*-phenylene dibiguanide salts besides the free copper base have been described and the constitution of the complex discussed.

2. Complex compounds of biguanide with tervalent metals. Part IX. Hydroxo-aquo cobaltic *bis*biguanidine and its salts.

Priyadaranjan Rây *and* Sailaja Prasad Ghosh, Calcutta.

Diammino cobaltic *bis*biguanide complex has been prepared from the oxidation of cobaltous biguanide in presence of ammonia. The removal of ammonia from the latter with consequent hydrolysis in aqueous solution has led to the production of hydroxo-aquo cobaltic *bis*biguanide complex, resembling the corresponding chromium derivative. A series of salts, viz. sulphate, chloride, nitrate, dithionate, sulphite and thiosulphate, have been prepared, besides the free hydrated base. The last-named, on dehydration, gave rise to a diol-dicobalti-tetra*bis*biguanide. The violet thiosulphate, on treatment with water or with an excess of sodium thiosulphate, gave a green insoluble product which proved to be a μ-thiosulphato-tetra*bis*biguanide dithiosulphato-dicobalt. The complex hydroxo-aquo sulphate gave on dehydration a sulphato-hydroxo cobaltic *bis*-biguanide with elimination of the aquo-group from the complex by the sulphato-radical.

3. Co-ordination compounds of cadmium with naphthylene diamines.

Kanai Lal Mandal, Calcutta.

The halides of cadmium (chloride, bromide and iodide) form co-ordination compounds with 1 : 8 naphthylene diamine in which two molecules of the diamine combine with a molecule of the cadmium halide. Similar *bis* salts are also formed by the chloride, the bromide and the iodide of cadmium with 1 : 2 naphthylene diamine. The complex cadmium halides are soluble in alcohol and ether. They also dissolve in amino compounds like pyridine and piperidine. The compounds are easily decomposed by alkalis and boiling acids.

4. On the formation of pyridine complexes by perchlorates.

P. C. SINHA *and* R. C. RAY, Patna.

A systematic study on the nature and composition of pyridine complexes of perchlorates of the metals belonging to the different groups of the Periodic Table has been attempted. The pyridine complexes of the perchlorates of copper, barium, cadmium, zinc, mercury and nickel have been described. Sodium and potassium perchlorates do not appear to form any complex with pyridine. The highest pyridine complex obtained with the perchlorates of copper, barium, cadmium, mercury and nickel may be represented by the general formula, $M'' . (ClO_4)_2 . 6$ pyr., where M'' is any of these five metals, but the highest complex in the case of zinc is $Zn(ClO_4)_2 . 4$ pyr.

The perchlorates were prepared by dissolving the freshly prepared and thoroughly washed hydroxides or oxides or carbonates of the metals in pure perchloric acid and crystallizing out the salts. They were purified by recrystallization and their purity tested by analysis. The perchlorate was dissolved in redistilled pyridine, and the pyridine complex was crystallized out from the solution. The crystalline form of the pyridine complex, which was fairly stable, was entirely different, in every case, from that of the original perchlorate. The complexes were dried on a porous plate over sulphuric acid and analyzed.

The constitution of these pyridine complexes has been discussed. Further work is in progress.

5. New compounds of gallium. Part IV. Gallium hydroxy-ammonium alum and double sulphates of gallium and primary, secondary and tertiary aliphatic amines.

P. NEOGI *and* KANAI LAL MANDAL, Calcutta.

Gallium sulphate has been made to combine with hydroxylamine sulphate and sulphates of primary, secondary and tertiary aliphatic amines. Hydroxylamine has yielded an alum crystallizing from water with 24 molecules of water. The double sulphates containing amine sulphates contain less than 24 molecules of water, some containing 16 and others 18 molecules. Double sulphates of two primary, one secondary and two tertiary amines have been obtained.

6. Double sulphates of aluminium and primary, secondary and tertiary amines. Part I.

P. NEOGI *and* KANAI LAL MANDAL, Calcutta.

Double sulphates of aluminium and *iso*-amylamine, *iso*-butylamine, diethyl amine, tri-*iso*-amylamine, tri-methyl amine have been obtained and others are in course of preparation.

7. Rolling properties of certain coinage metals and alloys in relation to their crystal structures (grain).

G. C. MITTER, Bombay.

Rolling properties of a metal or alloy is dependent to a great extent upon the structure. A coarse-grained structure does not lend itself to be rolled easily as a fine-grained one as also a crystal which has a comparatively low degree of symmetry. Cast zinc ingot, for instance, is composed of columnar crystals which are weaker along certain planes. The cracking of ingots of zinc when cold-rolled is due to this weakness in the crystals themselves and is not due to defects in the grain boundaries. Annealing, therefore, is not helpful in the rolling of a zinc bar. Hot rolling, however, helps the fragile columnar zinc crystals to develop slip planes and simultaneously amorphous material. At the temperature of rolling this amorphous material crystallizes into very fine equiaxial form. Once this is formed it can be cold-rolled without cracks, and this happens at 40% reduction in the case of zinc. Formation of fine and equiaxial crystals has been attempted to be induced by inclusion of small quantities of foreign elements, e.g. Cd, Fe, etc., but with no marked success. Magnesium behaves very like zinc.

In a case where the crystals themselves are not of a fragile type, cold-rolling may be permitted up to a certain degree. A copper-silver-manganese alloy (70·25·5%) on rolling gets work-hardened. Annealing has but little effect on the hardness of the strap as the crystals are rendered thereby coarse.

There is thus a critical range of cold-rolling which produces coarse crystals on subsequent annealing. The reduction is, therefore, to be carried well below this critical range, then annealed and rolled again, and so on till the desired thickness is obtained. It is, therefore, seen that to obtain a structure for subsequent fabrication a judicious combination of rolling and annealing condition must be worked out.

8. Reduction of stable oxygen containing compounds by aluminium and by metallic carbides.

D. D. KARVE, K. K. DOLE, *and* S. S. BHATE, Poona.

Reduction of calcium sulphate by aluminium has been studied. The reaction in the earlier stage is a solid-liquid heterogeneous reaction and in the later stages it may be a homogeneous liquid or a heterogeneous liquid-liquid system. The reaction is very vigorous and free sulphur is often produced during its progress, especially if aluminium happens to be in excess. In sulphates like copper sulphate the reaction yields copper in the metallic condition. Calcium carbide is a feeble reducing agent when compared with aluminium. It reduces chlorides more easily than oxides or sulphates. The temperature of the reaction is much lower than in the Alumino-Thermic reactions.

9. Studies in ammonia formation from active nitrogen and hydrogen.

S. S. JOSHI *and* VENKATESHWAR RAO, Benares.

Results of experiments carried out with a view to investigate the precise working conditions for the production of ammonia from active nitrogen have been recorded. Nitrogen, activated by a condensed electrical discharge, was allowed to strain at a constant rate and to interact with a fixed amount of the catalyst kept about 80°C. for half an hour. This was then replaced by a stream of hydrogen, *pre-heated and also pre-subjected to electrical discharge.* The effluent gases were then bubbled through a standard sulphuric acid solution and the ammonia formed, estimated. The selection of catalysts was made from the results of Joshi, K. Lakshmana Murty and Deekshitulu (for summary, see *Proc. Ind. Sci. Cong.*, 1941, Part III, p. 49).

The yields were comparatively low with the following catalysts: cadmium and lead; phosphate, carbonate and sulphate of magnesium; calcium sulphate and the potassium alum; lithium phosphate, cobalt oxide, nickel oxalate, monazite, dextrose and *activated carbon.*

There was, however, a better yield with zinc, copper, silicon, arsenic, antimony and iron; barium, strontium and cerium sulphates; borate and arsenate of barium; cadmium tungstate, mercurous sulphate and mercuric and cuprous cyanide, lithium carbonate and benzoate, 'hypo', potassium ferricyanide, antimony trioxide, vanadium pentoxide, iron oxide, cobalt oxalate and starch. An attempt to arrange the catalysts in order of activity shows alloy of tin and lead>magnesium>'rose' metal>tin, aluminium carbide>borax>lead borate>magnesium tartrate>sulphur> bismuth sulphate>iron oxalate.

It was interesting to note that while metallic magnesium possesses high activity, that of its compounds is comparatively poor. A remarkable feature of the present method is that the activity of any of the 100 catalysts now investigated, remains practically unimpaired when subjected to almost indefinite alternate streams of the activated gases, except in the case of the tin-lead alloy which has been found to give markedly greater yields of ammonia than metallic magnesium.

Production of a nitride or an adsorption complex would appear to be the main reaction in the first stage when active nitrogen is streamed; this reacts subsequently to give ammonia when activated hydrogen is passed. It is considered that the efficiency of the catalyst depends not so much on its capacity for its initial interaction with nitrogen, as on the reactivity towards activated hydrogen. It was also found that substances like cadmium tungstate, lithium benzoate and starch which exhibited pronouncedly brilliant luminescences with active nitrogen, gave but poor yields of ammonia.

10. Comparative studies in the behaviour of 'active manganese' prepared by different methods.

H. K. Joshi, Benares.

Addition of 10–15% 'artificial manganese dioxide' or the so-called 'active manganese' to the naturally occurring pyrolusite is known to have a marked influence in improving the depolarization characteristics of dry cells and in increasing the output. The present paper reports the results of using samples of 'artificial manganese dioxide' prepared by different methods. With a fixed proportion of the material, viz. 15% by weight of the total pyrolusite used in preparing the cell, characteristic voltage-time curves for various cells were obtained: The cell was discharged through a constant 5 ohm resistance for half an hour every day and its P.D., on open and closed circuit before discharge and with closed circuit after discharge, was noted. These observations were continued until the cell P.D. fell to 0·75 volt. The energy output expressed in W.H. (watt-hours) was then calculated. It was found that this last quantity depended not only upon the quantities and the relative proportions of the various chemicals and accessory materials constituting the inter-electrode space, but also upon such factors as the physico-chemical condition of the pyrolusite ore, the graphite and the starch used, the compression pressure in forming the 'dolly', the time of its 'cooking', and the relative spacing of the electrodes. These factors were not regulated with a view to produce cells of high energy output; the object rather was to get, within the limitations of the available accessories, comparable data for the cell performance as represented by the discharge curves.

The 'artificial manganese' samples were prepared by the following methods: (i) precipitation from aqueous manganous chloride and sulphate by permanganate, (ii) precipitation from manganous sulphate by sodium hypochlorite, (iii) decomposition of manganese carbonate by heating to about 300°C, (iv) decomposition of manganese nitrate, (v) as a by-product in the preparation of manganese salts from $Mn_3O_4(2MnO \cdot MnO_2)$.

Cells prepared with the above samples of 'artificial manganese dioxide' showed marked increase of output over the cells prepared with the natural pyrolusite ore. The rise in the output of the cells has been found to be different with samples prepared by different methods within a range of 0·5–1·0 W.H. Addition of 15% of samples No. (iii) and (iv) showed an increase of about 0·5 W.H. over normal, i.e. when 'active manganese' was not introduced. The material prepared by both the methods under (i) gave an increase of 1 W.H. In some cases the quality has been found to differ with the conditions of preparation of the samples. The approximate order for the activity of the 'artificial manganese' prepared by the above method is (i)>(v)>(ii)>(iii)>(iv).

An attempt has also been made to correlate the activating power of the above samples with their physico-chemical properties: water of hydration, particle-size, oxygen content, etc. The most efficient of the above samples was found to consist of sub-angular particles showing surfaces of sub-conchoidal fracture.

11. Electrochemical preparation of hydrogen peroxide. Part I. Preparation of persulphuric acid.

S. S. Joshi, D. N. Solanki *and* K. Sheshadri, Benares.

Literature shows that optimum conditions for the production of persulphuric acid are available at lower temperatures, 0–5°C. To maintain the electrolytic baths at such low temperatures is particularly difficult in India. An attempt has, therefore, been made to define a set of conditions for optimal yields of persulphuric acid at a temperature of 20°C, which can easily be maintained. The present investigation deals with the electrolytic production of persulphuric acid from sulphuric acid by using platinum electrodes and high anodic C.D.'s and the distillation of this product under reduced pressure to give hydrogen peroxide. In this connection the influence of the following factors have been studied: (i) sulphuric acid concentration, (ii) C.D.'s at either of the electrodes and their ratio, (iii) temperature, (iv) inter-electrode distance and disposition of the electrodes, (v) cathode material, (vi) current concentration, (vii) superposition of A.C. on D.C., and (viii) addition agents. Results under (i), (ii), (iii) and (vi) are of special interest.

The high current efficiency during the earlier stages of the electrolysis gradually diminishes with the progress of time and finally attains a zero value at a steady state, depending upon the C.D., temperature and current employed. A discussion of the various view-points of different workers leads to suggest that (*a*) the chemical decomposition of Caro's acid, and (*b*) anodic depolarization of hydrogen peroxide need be considered along with the main anodic reactions in the electrolysis of sulphuric acid, in accounting for the attainment of the steady state.

12. Electrochemical preparation of hydrogen peroxide. Part II. Distillation, concentration and stabilization of hydrogen peroxide.

S. S. Joshi, D. N. Solanki *and* K. Sheshadri, Benares.

The distillation of persulphuric acid for the manufacture of hydrogen peroxide has been the subject of considerable interest both theoretically and technically. Exact details of the process are not known, though innumerable patents on the subject are available. A solution of hydrogen peroxide decomposes rapidly when heated to 100°C. even if the solution be dilute. Experiments carried out to distill persulphuric acid under reduced pressures show a considerable loss (95%) of the total active oxygen during the process of heating. Passing of steam, if the electrolyte is cooled, however, brings about 100% hydrolysis; the loss of active oxygen is very much less. Experiments were then made to distill H_2O_2 (after hydrolysis) under reduced pressures; the loss of active oxygen under these conditions was considerably less. The H_2O_2 obtained is, however, very dilute and had to be concentrated. This was carried out by two methods—(i) concentration on a water bath, (ii) concentration under reduced pressure—with the results that under (i) a loss of 35% of H_2O_2 occurred due to evaporation, and under (ii) a 3% H_2O_2 was obtained without much loss.

The stabilization of hydrogen proxide was studied with a series of organic substances as preservative. Traces of acetanilide, glycerol, ethyl alcohol, ethylene glycol, etc., preserve the strength of hydrogen peroxide over a considerable length of time (recorded up to 1 month).

A comparative study was also undertaken of the electrolysis of saturated solution of ammonium sulphate under differing conditions of temperature, C.D. and current concentration. Our results show that sulphuric acid method due to its simplicity is preferable to the ammonium sulphate method.

13. Electrochemical preparation of permanganic acid by the electrolysis of manganous sulphate and sulphuric acid.

D. N. SOLANKI *and* M. PRABHANJANA MURTHY, Benares.

The technical method for the production of chromic acid by the electrolysis of chromium sulphate and sulphuric acid suggests the possibility of a similar method for permanganic acid. To investigate the optimum conditions for the maximum production of permanganic acid, a detailed study has been made of the electrolysis of manganous sulphate and sulphuric acid between two platinum electrodes, arranged *horizontally*.

The influence of the following factors on the production of permanganic acid has been studied: (i) concentration of sulphuric acid, (ii) concentration of manganous sulphate, the depolarizer, (iii) the temperature, (iv) the duration of electrolysis, (v) anodic C.D., (vi) cathodic C.D., (vii) the current concentration, (viii) the inter-electrode distance, and (ix) addition of foreign substances or catalysts.

In each of these items results of wide technical interest have been obtained. A plausible explanation has also been attempted for the mechanism involved in the formation of permanganic acid in presence of sulphuric acid.

In all the experiments reported, manganous sulphate used is prepared from the cheap raw material, pyrolusite, by its reduction with carbon and subsequent treatment with sulphuric acid under *optimum* conditions, which have also been worked out.

14. Electrolysis of chromium sulphate and sulphuric acid in the presence of manganous sulphate.

D. N. SOLANKI *and* M. PRABHANJANA MURTHY, Benares.

Electrolysis of sulphuric acid in presence of manganous sulphate gives permanganic acid while in presence of chromium sulphate it produces chromic acid. It is of interest to examine the behaviour—*whether there will be a preferential* oxidation of one or both the depolarizers—on electrolysis of a mixture of chromium sulphate and manganous sulphate in sulphuric acid medium. The present paper reports data as to the influence of the addition of manganous sulphate in the electrolysis of chromium sulphate and sulphuric acid. It was observed that the relative proportions of the two depolarizers [$MnSO_4$ and $Cr_2(SO_3)_4$] play a very important part in the anodic process. A detailed study brings out many important facts of practical interest. An explanation of the facts observed has also been given.

15. Studies in the permanganate formation in the electrolysis of fused alkali nitrates and the pyrolusite.

G. P. SINGH, Benares.

An alkali nitrate and manganese dioxide do not, as a rule, interact to give the permanganate. Joshi and Chandrakant (*Proc. Ind. Sci. Cong.*, 1940, Part III, pp. 40-41), however, observed that the above materials produce the permanganate *on electrolysis in the fused state*. Joshi, Solanki and Damri Singh (*ibid.*, pp. 116-117) have studied subsequently the influence of about 50 materials tried as catalysts. In view of the obvious importance of this process, as it proceeds without requiring extraneous alkali, the following experiments were carried out in order to obtain more information in regard to its scope of applicability and the reaction mechanism.

It has been observed by Joshi and co-workers (*loc. cit.*) that the alkali nitrite is one of the residual products of the above electrolysis, alkali manganate being the other. The presence of the former is a source of great difficulties as it exerts powerful reducing action on acidification, which is necessary for the transformation of the manganate into permanganate. For the same reason, the estimation of the formed permanganate is interfered with.

Attempts were, therefore, made to investigate whether the residual nitrite could be employed to give permanganate by further electrolysis with fresh MnO_2. The results were not satisfactory, since a very preponderating excess of the nitrate is needed for converting but a small amount of MnO_2 (about 1/15 its weight) into permanganate by the present method. Incidentally, interesting observations have been made on the possible production of nitrous oxide in the above electrolysis, when soft iron electrodes were used.

The addition of NaCl, $MgSO_4$, Na_2SO_4, K_2SO_4 in various proportions of the electrolytic melt had no influence in advancing from the stage of the manganate formation.

Results of a comparative study, *in the presence of extraneous alkali*, show that the thermochemical method gives better yields than the electrochemical. *In absence of alkali*, however, the latter is the only available procedure.

16. Electro-deposition of bronze on copper.

D. N. Solanki *and* U. S. Dhar, Benares.

The optimum conditions have been worked out for a smooth, bright and adherent deposit of bronze on copper as a base metal from an alkaline cyanide bath containing $K_3Cu(CN)_4$ and K_2SnO_3. A detailed study has been made of the influence on the quality and structure of the deposit, as examined microscopically, of the following factors: (i) electrolyte concentration, (ii) current density at the cathode, (iii) duration of electrolysis, (iv) temperature, and (v) addition agents. Addition in traces of gelatine, dextrine, $CdSO_4$, $8/3H_2O$, H_2O_2 (1%) and pyrogallol to the bath solution improves the deposit markedly by minimizing the grain size. In presence of tannic acid, glycerol, $Na_2S_2O_3$ and lactic acid the deposit gets spoiled due to blackening effect.

17. Sodium zincate.

S. M. Mehta *and* M. B. Kabadi, Bombay.

Solutions of sodium zincate containing varying proportions of ZnO : Na_2O were studied by the measurement of the electrical conductivity of these solutions and the results were reported previously (*Proc. Ind. Sci. Cong.*, 1935, p. 113; *J. Ind. Chem. Soc.*, 1939, **16**, 223). The hydrogen ion concentration of these solutions was also determined using the glass electrode. From the data obtained in the latter it was concluded that it should be possible to isolate sodium zincate from solutions stronger than 8*N*. This conclusion has been realized and a salt of the composition Na_2ZnO_2, $3H_2O$ has been isolated from solutions which were 10*N* to 15*N*.

Further work is being continued on a study of the properties of solutions of alkali zincates.

18. The thermal decomposition of calcium sulphate in presence of boric oxide.

S. M. MEHTA *and* A. VENKATACHALAM, Bombay.

The effect of time factor in the decomposition of calcium sulphate in the presence of different amounts of boric oxide reported previously (*Proc. Ind. Sci. Cong.*, 1937, p. 124) was investigated. For this purpose the different mixtures of calcium sulphate and boric oxide in the molecular proportions (i) 1 : 1, (ii) 1 : 2, (iii) 1 : 3, (iv) 1 : 4, and (v) 1 : 5 were heated at temperatures 1000° and 1050°C. Results show that the decomposition is continuous up to two hours and that the relative proportion of sulphur trioxide is greater than that of sulphur dioxide.

The different mixtures were also heated in vacuum and the pressures generated were measured at different intervals of time. It is noticed that there is a continuous increase of pressure with time up to two hours and that the maximum decomposition is obtained with the ratio $CaSO_4 : B_2O_3 =$ 1 : 2 at 1050°C.

19. Thermal decomposition of calcium sulphate in presence of boric oxide and its mixtures with other metallic oxides.

S. M. MEHTA *and* V. G. FENANI, Bombay.

The investigation previously reported (*Proc. Ind. Sci. Cong.*, 1937, p. 124; vide previous abstract) has been further extended by a study of the decomposition of calcium sulphate in the presence of boric oxide and its mixture with V_2O_5, Fe_2O_3, Al_2O_3, Cr_2O_3 and TiO_2. The different mixtures were heated in an electric furnace between 900° and 1050°C. The decomposition was studied by measuring the pressures generated by the gaseous products of decomposition at different intervals of time, since the attainment of a given temperature. The gaseous products of decomposition as well as the residue left in the furnace tube were analyzed. The results support the observation previously made that the decomposition of calcium sulphate-boric oxide mixtures gives mostly sulphur trioxide with a relatively small amount of sulphur dioxide. It is found that the pressure becomes constant after forty-five minutes in the case of V_2O_5 but with the other metallic oxides it increases up to two hours. Under identical conditions the highest decomposition is obtained with Fe_2O_3.

Physical Chemistry

20. Studies in glass systems: polar crystals in B_2O_3-glass.

SUBODH KUMAR MAJUMDAR, Calcutta.

Majumdar and Sarma have recently shown from refractometric measurements that polar crystals are strongly deformed in boric oxide glass in the sense demanded by the Fajans' theory. In this investigation an attempt has been made to study the Debye-Scherer diagrams of different samples of B_2O_3-glass containing varying amounts of LiCl, NaCl, KCl, RbCl and CsCl. An objection has been raised that the alkali halides may undergo change while entering into the composition of the glass systems. To meet this, both the chlorine and the alkali metal contents have been analytically determined and have been found to conform to the stoichiometric ratio 1 : 1. The glasses have then been examined by the powder photography method. Results obtained have been compared with those for the pure crystals and certain interesting departures have been noticed.

21. Decomposition of chromates at high temperatures.

D. S. Datar *and* S. K. K. Jatkar, Bangalore.

The heats of decomposition of the various mixed basic chromium chromates have been calculated by the application of Nernst Heat Theorem using more accurately determined decomposition pressures.

The measurements of vapour pressures at various stages in the oxidation of calcium chromate does not indicate the intermediate stages above 50% decomposition. A critical study of the accuracy of the previous data in the decomposition of calcium chromate and of chromic oxide indicates that the higher stages observed are due to the formation of the lower stages, the extra chromium trioxide remaining as a separate phase.

22. The C—H←Cl bond.

(Miss) Nagamani Shama Rao *and* S. K. K. Jatkar, Bangalore.

The molecular polarization curves of the systems benzene-carbon tetrachloride, -chloroform, -methylene dichloride, -ethylene dichloride, -ethylene dibromide and the selective adsorption curves by activated carbon and silica gel are highly anomalous. The results can be explained on the basis of existence of molecular complexes of benzene with the number of carbon halogen bonds. The known examples of hydrogen bonds involving CH linkage with nitrogen and oxygen, will have to be extended to the case of aromatic $CH \leftarrow Cl^-$.

23. The dispersion of dielectric constant.

(Miss) Nagamani Shama Rao *and* S. K. K. Jatkar, Bangalore.

The dispersion of dielectric constants of the systems C_6H_6—$CHCl_3$, —CH_2Cl_2, —CH_2ClCH_2Cl and —CH_2BrCH_2Br and ethyl alcohol has been measured with a view to find the effect of complex formation on dispersion. The influence of traces of moisture on the anomalous dispersion of acetone and ethyl alcohol has been investigated. The dispersion of nitrobenzene in viscous oils is anomalous above 10 megacycles.

24. Kinetics of hydrogenation of oils by continuous process.

R. V. Joglekar *and* S. K. K. Jatkar, Bangalore.

The space-time yields, the apparent (K) and the corrected velocity coefficients (K') have been calculated for the hydrogenation of safflower, sesame, cottonseed and groundnut oils. The maxima at 140° in the K-temperature curve has been attributed to the higher velocity of the hydrogenation of olein at that temperature. The values 1, 2 and 4 obtained for the exponent n in the equation $K = K'(R)^{\frac{1}{n}}$ have been shown to be due to the activated adsorption of hydrogen, olein and linolein respectively. The heats of activation calculated for oils containing different percentages of olein and linolein have shown that the heats of activation are 2 K.cals and 8 K.cals for olein and linolein respectively.

25. The relation between density, vapour pressure and chemical constitution.

R. K. Sharma, Lahore.

It has been shown that the density and vapour pressure of unassociated compounds are simply related to each other. If the density of the unassociated compounds at the boiling point (760 mm.) be multiplied by such a factor that the compounds may have the same density at the boiling point then any density whatsoever multiplied by that factor for the given compound and plotted against the vapour pressure observed at the same temperature, will fall on a single curve for all of these substances.

Mathematically $$\frac{\rho_\gamma}{\rho} = K_1$$

where ρ_γ represents the density of the standard substance at a certain pressure;

ρ represents the density of any other substance at the same pressure.

This relationship is found to be independent of temperature.

If this constant K_1 is multiplied by M (molecular weight of the substance), we get another constant K_2

$$M \times K_1 = K_2.$$

This K_2 can be used to determine the constitution of substances both organic and inorganic and gives fairly reliable results and the structural constants of various elements are calculated by this method.

26. Kinetics of the decomposition of potassium chlorate, heated in the presence of oxides and salts of titanium, vanadium, chromium, manganese, iron, cobalt, nickel and copper.

G. B. KOLHATKAR *and* U. A. SANT, Poona.

Potassium chlorate is mixed in the proportion of 10 : 1 with TiO_2, Cr_2O_3, MnO_2, Fe_2O_3, Co_2O_3, Ni_2O_3 and CuO. In the presence of the above oxides, potassium chlorate decomposes at a temperature lower than when heated alone. At the temperature, when appreciable evolution of oxygen occurs, the decomposition is also studied as a time reaction. Potassium chlorate is also mixed in the proportion of 10 : 1 with sulphates of titanium, chromium, manganese, iron, cobalt, nickel and copper, and with the chloride of vanadium. The decomposition of the chlorate, in the presence of these salts, occurs at a temperature lower than that with oxides. At the temperature, at which appreciable evolution of oxygen occurs, the decomposition is studied as a time reaction. The results obtained show that the decomposition of potassium chlorate in the presence of salts is a bi-molecular reaction.

27. Vapour pressures of HCl and HBr in carbon-tetrachloride, hexane and in solutions of substituted anisols in carbon-tetrachloride and hexane.

S. P. WALVEKAR, N. L. PHALNIKAR, *and* B. V. BHIDE, Poona.

Modified method of Saylor (*Proc. 28th Ind. Sci. Cong.*, 1941, Part III, p. 50) has been used for the measurements of vapour pressures of HCl and HBr in carbon tetrachloride and in hexane. Vapour pressures of HCl and HBr in solutions of various concentrations of substituted anisols in the above solvents have been also determined.

The vapour pressures of HCl and HBr in solutions of substituted anisols in carbon tetrachloride show a marked depression, indicating compound formation. The equilibrium constants of such compounds have been determined and are correlated with the dipole moments and velocity of hydrolysis of the substituted anisols. Similar experiments carried out in hexane solutions give similar results.

28. Dielectric constants of inorganic salts.

N. V. SATHE, N. L. PHALNIKAR, *and* B. V. BHIDE, Poona.

The method of mixture of K. HöJendahl (*Z. physikal Chem.*, 1933, **B20**, 54) has been used for the determination of the dielectric constants of inorganic salts. The dielectric constants and densities of the halides of sodium, potassium, silver, mercury, lead and copper have been determined. From their dielectric constants, the relation between the nature of the bond and polarization has been discussed. The two forms of HgI_2 have also been studied. The yellow form is definitely more of a covalent type than the red variety. Silver halides are electrovalent. Molecular refractions of some of these salts have been discussed in the light of the dielectric polarization measured. Further work is in progress.

29. Viscosity of mixed solutions containing three and four ionic species.

AMRITANSU SEKHAR CHACRAVARTI *and* BALBHADRA PRASAD, Cuttack.

Viscosity of two binary electrolyte mixtures with common cations and two without common cations (each in three different proportions) as well as the viscosity values for solutions of three simple electrolytes are reported. Onsager and Fuoss' limiting law for mixed ionic solutions has been established in three cases and an equation of the Jones and Dole type applied to the results. The coefficient of the square root term 'A' has been shown to be a linear function of composition. The same is true of the coefficient of the linear term 'B', except in the case of NaCl–$BaCl_2$ mixtures, whose results are taken from a previous paper. The additive principle is not applicable to the viscosity of a mixed solution of two electrolytes, the observed values being systematically too low. This behaviour has its parallel in the conductance and transference numbers in mixed electrolyte solutions.

30. The supersaturation limits of solutions.

A. C. CHATTERJI *and* RAMA GOPAL, Lucknow.

In order to get some idea about the supersaturating power of a solvent, e.g. water for different solutes and its dependence on any property of the entities concerned, aqueous solutions of different substances free from germ crystals as far as possible, were sealed in well-steamed and dried test tubes. These were allowed to cool slowly in a beaker containing water. It is found that in a number of cases there is a definite temperature for every solution at which crystallization sets in spontaneously. The difference between the saturation temperature T and that of spontaneous crystallization T', that is $T-T'$, is almost constant for the same solute whatever the saturation temperature may be. But this quantity is different for different solutes. For a number of potassium salts, it is found that the greater the equivalent heat of solution, lesser the degree of supersaturation, i.e. the smaller the supersaturating power of the solvent. It has been observed that in most cases the greater the temperature coefficient of solubility, lesser the supersaturation or smaller the supersaturation limit. This statement is, however, not very strictly true.

There are other cases in which no definite temperature of spontaneous crystallization is obtained, although each solution seems to reach a lower constant limit at which crystallization necessarily occurs. The crystallization at this lower limit is almost instantaneous. It is not possible to account for this anomaly at the present stage of investigation. A detailed study of supersaturation limits is still in progress in this laboratory.

31. Dilatometric studies on supersaturation. Part I.

A. C. Chatterji *and* Rama Gopal, Lucknow.

That there occurs no sudden change in volume at the saturation temperature when a solution is cooled from unsaturated to the supersaturated state, has been confirmed in the cases of solutions of potassium nitrate, potassium sulphate, sodium nitrate, oxalic acid and sodium acetate. Further it has been shown that inflexions in temperature-volume curves of cooling solutions occur only when crystallization takes place, either automatically or is induced artificially by inoculation. It appears to be fairly established that there occur no abrupt changes in the molecular state at the saturation temperature, and if these occur at all, variations are perfectly regular. An attempt has also been made to show that no sudden changes, which can be exhibited as changes in volume of a cooling solution, occur in the molecular state at the lower limit of the metastable range, i.e. at the labile temperature.

32. A statistical study of the variation of specific conductivity with concentration of electrolytes in aqueous solution.

Rama Gopal, Lucknow.

When the specific conductivity of an electrolyte is plotted against the percentage concentration, in a large number of cases it has been found that the curve passes through a maximum at about 20% to 30% concentration. There are a few marked exceptions, however, to this rule. On a statistical study it has been observed that the electrolytes, in general, can be divided into two classes. The first one includes those electrolytes for which the conductivity-concentration curves do not pass through a maximum. To this category belong the sodium, ammonium and the potassium salts of inorganic acids (HCl, HNO_3, H_2SO_4, HBr and HI). To the second class belong, in general, the rest of the soluble salts, e.g. $LiNO_3$, LiCl, $Cu(NO_3)_2$, $CuSO_4$, $CaCl_2$, $Ca(NO_3)_2$, etc., all the acetates, carbonates, acids and hydroxides. It has been further observed that, in general, for the same anion and different cations the maximum occurs at almost the same equivalent percentage concentration. It has been possible to explain this phenomenon on the hypothesis of selective hydration of ions, somewhat analogous to the ionic hydration hypothesis of Sugden (*Jour. Chem. Soc.*, 1926, **174**, 196), according to which only the cations in solution are hydrated but not the anions.

33. Ionization constant of iodic acid.

M. R. Nayar *and* Ramgopal, Lucknow.

Both the classical (Ostwald) constant $K_c = \frac{\alpha^2 c}{1-\alpha}$ and the activity constant $K_\gamma = \frac{\gamma^2 c}{1-\alpha}$ of iodic acid of fifteen different solutions of concentrations ranging from $0{\cdot}01N$ to $1{\cdot}00N$ have been determined from conductivity measurements at 20°C and 30°C. While the values of K_c were found to be varying while those of K_γ were constant within two ranges studied.

Beyond $0{\cdot}1N$ K_γ shows a gradual decrease in the value as the concentration is increased. The two regional constants indicate the existence of transition points at $0{\cdot}04N$ and $0{\cdot}10N$. These correspond to the breaks in the curves of the various physical properties of the acid solution, namely: density, viscosity, parachor, refractive index, magnetic susceptibility, temperature coefficient of conductivity, etc. These breaks were interpreted as transition points in the depolymerization of iodic acid molecules, the course of reaction from concentrated to dilute solutions being:

$$\tfrac{1}{3}(HIO_3)_3 \xrightarrow[0\cdot 1N]{} \tfrac{1}{2}(HIO_3)_2 \xrightarrow[0\cdot 04N]{} HIO_3 \longrightarrow H^+ + IO_3^-$$

These polymers are monobasic acids corresponding to the two well-known acid salts of iodic acid.

34. Influence of nonelectrolytes on the decomposition potential of aqueous silver nitrate.

D. N. SOLANKI, Benares.

The present investigation has been carried out with a view to examine the influence of medium on the decomposition potential of silver nitrate. The decomposition potential of the aqueous salt ($N/10$) has been measured by the graphical method, at 30°C., in the presence of the non-electrolytes—ethyl alcohol, glycerine, acetone and pyridine, whose concentrations were varied within wide limits. Results show that the potential practically remains unaltered (0·75 volt) despite the presence of large proportions of non-electrolyte (except acetone) in the system. This may probably be attributed to the absence of interaction between the ions of the solute and the medium. The presence of acetone (5%), however, raises the decomposition potential of $N/10$-$AgNO_3$ from 0·75 to 0·85 volt. Its increased concentration up to 50% produces no further change. This may probably be due to the formation of a stable complex of silver nitrate with acetone present in various water-acetone mixtures used. It is also probable that the heat of solution of silver nitrate may be considerably affected by acetone present in the system; which is however absent in the case of ethyl alcohol, glycerine and pyridine. Data are also given for the conductivities of the corresponding solutions.

35. Transport number and conductance measurements of aqueous cadmium sulphate in the presence of non-electrolytes.

D. N. SOLANKI, Benares.

Transport number (by Hittorf's method) and conductivity measurements have been made at 25°C., for aqueous cadmium sulphate ($M/15$), in the presence of varying quantities of the non-electrolytes—sucrose, urea, ethyl alcohol and acetone. Results show that the transport number of the cadmium ion at first increases steadily with the concentration of the non-electrolyte, except in the case of urea, until it reaches a limiting value; it then diminishes with further addition. This appears to be more pronounced in the case of ethyl alcohol and acetone. The results may be explained on the assumption that, in cadmium sulphate solutions, hydration or solvation has relatively less influence on the SO_4'' ion than on Cd^{++} ion. The observed changes may, therefore, be due principally to a diminution in hydration of Cd^{++} ion with increasing concentration of the non-electrolyte followed by increase in solvation.

It is interesting to note that addition of fairly large amounts of urea (up to 10%) seems to have very little effect on the transport-number of Cd^{++} ion; neither is the conductivity altered. It appears that the hydration of Cd^{++} ion is very little affected under the stated conditions.

36. Relation between the constitution of glass and the potential at glass electrolyte interfaces.

R. C. RAY, P. B. GANGULY, *and* B. P. SARKAR, Patna.

In this investigation it has been found that powdered glass enters into the same type of equilibrium as sparingly soluble salts in electrodes of the second type. An attempt has been made to correlate this behaviour with the constitution of glass.

A sample of glass was prepared by fusing together sodium carbonate, calcium carbonate and washed silica in an electric furnace. This was finely powdered and used in setting up the following cell:—

$$\text{Ca, Hg.} \left| \begin{array}{l} \text{powdered glass} \\ K_2SiO_3 \text{ solution.} \end{array} \right\| \text{Calomel.}$$

A 0-0'7% amalgam was prepared by electrolysis of calcium chloride according to the method of Fosbinder (*Jour. Amer. Chem. Soc.*, 1929, **51**, 1349) and used. For the above cell the following expression applies $E_1 - E_2 = z/(x+y) \,.\, RT/nF \,.\, \log n$, where E_1 and E_2 are the e.m.f.'s corresponding to potassium silicate solutions of concentrations c_1 and c_2, $(c_1/c_2 = n)$ and x, y, and z are the numbers of sodium, calcium and silicate ions respectively furnished by glass. From the data $(x+y) = 2z$, which agrees with the simple formula Na_2O, CaO, $6SiO_2$.

37. The electrical conductivity of aqueous solutions containing boric acid and hydroxylic substances.

S. M. MEHTA *and* (MISS) K. V. KANTAK, Bombay.

The molecular conductivity of boric acid in the presence of varying amounts of hydroxylic substances, viz. mannitol, sorbitol, laevulose, glucose, galactose, mannose, xylose and tartaric acid was measured at 30°C. by Kohlrausch's method. The molecular conductivities have been plotted against dilution and against the ratio boric acid: hydroxylic substance. It is found that the conductivity decreases with dilution but increases with an increase in the amount of the hydroxylic substance added. It is also noticed that the effect of the hydroxylic substances in increasing the conductivity is in the order sorbitol>mannitol, laevulose> mannose>xylose>galactose$\gtrless$glucose.

38. Hydrogen ion concentrations of aqueous solutions containing boric acid and hydroxylic substances.

S. M. MEHTA *and* (MISS) K. V. KANTAK, Bombay.

The H-ion concentrations of solutions containing boric acid and different hydroxylic substances, viz. mannitol, sorbitol, laevulose, galactose, mannose, maltose, malic, tartaric, oxalic and citric acids in different molar proportions were measured at 30°C. by the quinhydrone method in conjunction with the electrometer triode described by Mehta (*Jour. Univ. of Bombay*, 1936, **5**, (II), 77). It is found that laevulose is more effective than the other polyhydric substances such as mannitol, sorbitol and galactose in increasing the acidity of boric acid. The *p*H values obtained in this investigation in the case of laevulose are in good agreement with those of Boeseken, Vermans and Kuchlin (*Rec. trav. chim.*, 1930 **49**, 711) but differ from those of Krantz, Beck and Carr (*Jour. Phys. Chem.*, 1936, **40**, 151, 927) who are probably in error. The number of molecules of the polyalcohol (n) which combine with one molecule of boric acid have been calculated by means of the equation $n = \dfrac{2 \Delta pH}{\log a}$ given by Boeseken, Vermans and Kuchlin (*loc. cit.*).

39. Reduction of ceric tartrate sol in *d*- and *l*-circularly polarized ultraviolet light.

T. Banerjee, Dacca.

The unimolecular velocity constants of the photoreduction of ceric tartrate sol vary directly as the intensity of absorbed radiations (366 $\mu\mu$). With *d*- or *l*-tartaric acid photoreduction of ceric tartrate sol is more rapid in *l*-circularly polarized light than in *d*-circularly polarized light. But when racemic acid is used for the production of ceric tartrate sol, light in the two states of circular polarization is equally efficient. Moreover, ceric racemate sol, partially or completely reduced in *d*- or *l*-circularly polarized light exhibited no optical activity.

40. Photochemical after-effect in the bromine-oxalate reaction.

Bijan Bihari Lal, Lucknow.

A marked photochemical after-effect has been observed in the oxalic acid-bromine reaction. The after-effect persists for several hours after the illumination has been withdrawn and increases with increasing periods of irradiation up to a certain stage. If illumination is continued for longer periods, the after-effect is diminished. The study of the retarding action of hydrobromic acid, produced in the reaction, is under way and may explain this effect. The above results were obtained by using excess of potassium bromide in the oxalic acid-bromine reaction mixture. When the bromine that has been photochemically removed in the light reaction is restored in the end solution in the dark immediately after the completion of the photo-reaction, no 'secondary after-effect' is observed.

The photochemical reaction between potassium oxalate and bromine is also followed by a marked after-effect, which persists for several hours as in the case of free oxalic acid. When the dark reaction is allowed to proceed more rapidly by reducing the bromide concentration, no measurable photochemical after-effect is observed. This reaction also shows no 'secondary after-effect'.

The 'decay' of the photochemical after-effect is very rapid just after cutting off the illumination and is relatively slower afterwards. After four to five hours, the after-effect rates approach the normal dark rate. It appears that the active intermediate ion formed in the light reaction reacts with bromine giving the photochemical after-effect and is at the same time destroyed in other ways. The 'decay' of the photochemical after-effect, thus, cannot be represented by any kinetic equation.

From the above preliminary observations it appears that the photochemical reaction between oxalate and bromine produces a reactive univalent oxalate ion C_2O_2 which causes a more rapid bromine reduction in the dark, thus accounting for the after-effect. The persistence of the after-effect suggests that C_2O_4' forms an essential link in some chain mechanism and is alternately destroyed and regenerated. The decay of the after-effect may be due to the disappearance of C_2O_4' by self-combination:—

$$C_2O_4' + C_2O_4' = C_2O_4'' + 2\ CO_2.$$

A detailed investigation of the reaction is proceeding.

41. Absorption spectra in the ultraviolet of the substituted coumarins.

K. G. Naik, R. K. Trivedi, *and* M. P. Shah, Baroda.

In order to study the change taking place in light absorption when the structure of simple coumarin is modified by the presence of various substitutents, the following compounds were studied: (1) 7-Hydroxy-4-

methyl coumarin, (2) 7-Hydroxy-4-methyl-3-ethyl coumarin, (3) 7-Hydroxy-4-phenyl coumarin.

It was observed that (i) the presence of a cyclic structure attached to the coumarin molecule to the chromophore group $>C=C<$, considerably slows down the frequency of vibration of the molecule, which condition is translated by higher degree of light absorption and shifting of spectrographic curves towards the visible. (ii) Whenever a radical such as $-C_2H_5$ is introduced into the coumarin structure, the molecule becomes slightly heavier, thereby lowering the frequency vibration of the molecule. As a result, the light absorption is considerably modified.

42. Absorption spectra of the substituted cinnamic acids.

R. K. Trivedi *and* M. P. Shah, Baroda.

In order to study the 'Bathochromic effect', the following open-chain substituted cinnamic acids were studied and their spectrographic curves were compared with those of the corresponding close-chain substituted coumarins. (1) 2-4-Dimethoxy-β-methyl cinnamic acid, (2) 2-4-Dimethoxy-β-methyl-α-ethyl cinnamic acid, (3) 2-4-Dimethoxy-β-phenyl cinnamic acid. On comparison, it was found that the degree of light absorption is greater in the case of the open-chain structures (acids) than in the case of the corresponding cyclic structures, (the coumarins).

With regard to the effect produced by the substituting groups on the light absorption of the acids, it was found that the sum total effect of (i) introducing a $—C_6H_5$ group in the β-position, is to increase the general absorption to such an extent that the crest of the curve shoots up suddenly, the whole curve being shifted towards the visible. (ii) Accumulating $—OCH_3$ groups in the benzene nucleus is to flatten the bands.

43. Light absorption in the ultraviolet of the substituted amides of aceto-acetic acid.

K. G. Naik, R. K. Trivedi, *and* B. N. Mankad, Baroda.

The following substances were examined for the absorption spectra in the ultraviolet in aqueous solution: (1) aceto-acetanilide, (2) aceto-acet-*o*-tolylamide, (3) aceto-acet-*p*-tolylamide, (4) aceto-acet-1. 3. 4. xylylamide, (5) aceto-acet-*a*-naphthylamide, (6) aceto-acet-*b*-naphthylamide.

The important observations are: (i) The characteristic bands due to the presence of simple ketonic form are observed between the wavelengths 2800—2400 Å. This must be ascribed to the ketonic structure of the amides persisting in the aqueous solution as against the enol form observed by Mme. Ramart, Naik and Trivedi (*Bull. Soc. Chim.*, 1934, p. 525) from light absorption in alcoholic solutions. (ii) The disposition and the direction of the curves remain the same as in the absorption spectra observed in the previous work. Total effects of the groups carried by two carbonyl groups also remain the similar. (iii) Differences in disposition of the curves can be ascribed to differences in structure, because, in all the above cases the ester group $—COOC_2H_5$ has been replaced by groups such as $-CONHR$. (iv) The distinct difference between the curves of α-naphthylamide and *p*-naphthylamide is attributed to the structures of their amino residues.

44. Absorption spectra of the mono-chloro derivatives of the substituted amides of aceto-acetic acid.

K. G. Naik, R. K. Trivedi, *and* B. N. Mankad, Baroda.

The present work was undertaken to study the changes in light absorption by replacing hydrogen atoms of the central methylene group of the following compounds:—

(1) Mono-cholor-aceto-acetanilide, (2) mono-chloro-aceto-acet-1.3.4-xylylamide, (3) mono-chloro-aceto-acet-α-naphthyl amide.

Comparing the curves of these chloro-derivatives with those of the non-substituted amides, it was found that in the case of the chloro-derivatives: (i) the degree of light-absorption increases, (ii) the curves are shifted towards the visible.

45. Absorption spectra of *iso*-nitroso derivatives of the substituted amides of aceto-acetic acid.

K. G. NAIK, R. K. TRIVEDI, *and* B. N. MANKAD, Baroda.

The effect of complete transformation of the $-CO.CH_2.CO-$ group into $-CO.C:NOH.CO-$ in the following compounds on absorption in the ultraviolet has been studied: (i) *iso*-nitroso-aceto-acetanilide, (2) *iso*-nitroso-aceto-acet-*p*-tolylamide, (3) *iso*-nitroso-aceto-acet-1.3.4 xylylamide.

Observations made are as follows: (i) the bands have been conspicuously shifted towards the visible, as expected from the colour of the substances and from the condition of strain established by the double bond in the molecule; (ii) the crests of the curves in the case of the methylene compounds have been practically smoothened out due to change of structure; (iii) the relative position of these curves is the same as that of the non-substituted amides; (iv) the bases of these curves tend to be shifted towards the visible, with an indication for a general flattening.

46. Velocity of hydrolysis of the substituted amides of aceto-acetic acid.

R. K. TRIVEDI *and* B. N. MANKAD, Baroda.

The substituted amides of aceto-acetic acid mentioned below were hydrolyzed with a standard solution of (i) alcoholic potassium hydroxide, (ii) aqueous hydrochloric acid, in order to study the rate of hydrolysis in alkaline and acid media: (1) aceto-acetanilide, (2) aceto-acet-*o*-tolylamide, (3) aceto-acet-*p*-tolylamide, (4) aceto-acet-1.3.4-xylylamide, (5) aceto-acet-α-naphthylamide, (6) aceto-acet-β-naphthylamide.

The following observations have been made in this connection: (i) velocity of hydrolysis (especially alkaline) agrees with their absorption spectra, (ii) appears to depend upon the nature of the radicals attached to the hydrolyzable imino group, the position of the methyl group with respect to the imino group and the molecular weight of the radicals attached to the imino group, (iii) introduction of asymmetry increases the relative rate of hydrolysis.

47. Velocity of replacement of the chlorine atoms in the chloro derivatives of the substituted amides of aceto-acetic acid.

R. K. TRIVEDI *and* B. N. MANKAD, Baroda.

Chemical activity of the substances mentioned below as expressed by the velocity of replacement of the chlorine atom has been correlated with their absorption spectra: (1) mono-chloro-aceto-acetanilide, (2) mono-chloro-aceto-acet-1.3.4-xylylamide, (3) mono-chloro-aceto-acet-α-naphthyl-amide.

Results indicate that the following factors influence the velocity of replacement of the chlorine atom by hydrogen: (i) the position as well as the spatial arrangement of the radicals like the methyl groups, in the nuclear rings attached to the carbonyl groups of these groups; (ii) the unsymmetry of the group round the central carbon, resulting into unbalanced unilateral tension. The replacement of chlorine increases in rapidity as we pass from mono-chloro-aceto-acetanilide, through mono-chloro-aceto-acet-1.3.4.-xylylamide, to mono-chloro-aceto-acet-α-naphthylamide, it being the most rapid in the last case.

48. Chemical activity of the substituted cinnamic acids as expressed by the velocity of their esterification.

K. G. NAIK, R. K. TRIVEDI, *and* M. P. SHAH, Baroda.

A study on the velocity of esterification was undertaken with a view to study (i) the influence of the catalyst on the course of reaction; (ii) the influence exerted by the various substituting groups on the velocity of esterification, with the following substituted cinnamic acids: (1) 2-4-dimethoxy-β-methyl cinnamic acid, (2) 2-4-dimethoxy-β-methyl-α-ethyl-cinnamic acid, (3) 2-4-dimethoxy-*p*-phenyl-cinnamic acid.

The following facts were brought into relief: (i) in the absence of the catalyst (HCl) the acids could not be esterified, whereas in its presence esterification proceeded to a considerable extent; (ii) any substituent in the β-position influences the velocity of esterification almost equally; (iii) the presence of a substituting group in the α-position in acrylic acid chain, considerably lowers the velocity of esterification.

49. Velocity of replacement of bromine atom by hydrogen in the mono-bromo-derivatives of the substituted amides of aceto-acetic acid.

R. K. TRIVEDI *and* M. P. SHAH, Baroda.

The following substances were investigated in this connection: (1) mono-bromo-aceto-acetanilide, (2) mono-bromo-aceto-acet-*p*-toluidide, (3) mono-bromo-aceto-acet-1.3.4.-xylidide.

The factors influencing the velocity of replacement of bromine atom by hydrogen were found to be (i) the internal arrangement of the molecule as expressed by the unsymmetry of the groups round the central carbon atom of $-CH_2$-group, resulting into unbalanced, unilateral strain, (ii) the positions of the various radicals such as $-CH_3$ in the nuclear ring attached to the $>C=O$ groups, as well as the arrangements of these groups in space.

50. The effect of radiation on the decomposition potentials of aqueous hydrochloric, hydrobromic and hydriodic acids.

S. S. JOSHI *and* D. SINGH, Benares.

In view of the remarkable influence noticed recently by Joshi and co-workers in these laboratories on the variation by irradiation of the 'threshold potentials' and conductivity of a number of gases under electrical discharge, it appeared to be of interest to investigate the occurrence of a like effect in electrolytic solutions as no such information is available in the literature. A beginning has been made, therefore, in the work reported in the present paper, in the case of solutions of hydrochloric, hydrobromic and hydriodic acids on the electrolysis in silica cell between bright platinum electrodes at various concentrations and temperatures, subjected to radiations from a quartz mercury vapour lamp.

Results show that the decomposition voltage of hydrochloric acid increases with dilution and finally at dilutions $N/32$, $N/64$, and $N/128$, it corresponds to that of water; and oxygen is more easily liberated at the anode than chlorine. The decomposition voltage also diminishes with rise in temperature, the temperature coefficient being 0·001 to 0·002 between 10°–60°C. Similar results were obtained with hydrobromic and hydriodic acids.

Illumination of the anode only or of both the electrodes tends to diminish the decomposition potential, the illumination of the cathode, however, producing almost no effect. This tendency of diminution by illumination decreases with dilution till at the dilutions $N/64$ and $N/128$, it remains almost unaltered.

51. The effect of radiation on the conductivity of aqueous hydrochloric, hydrobromic and hydriodic acids.

D. SINGH, Benares.

The conductivity measurements of the halogen acids at different concentrations and temperatures were made both in dark and with bright platinum electrodes illuminated in a silica cell. The specific conductivity of the acids was found to increase on illumination, in the following descending order: $HCl > HBr > HI$. This effect diminishes with dilution. The observed results might, perhaps, be attributed to the opening up of the atomic fields of force between hydrogen and halogen ions brought about by ultraviolet light (cf. Leighton, *Jour. Phys. Chem.*, 1913, **17**, 695; and Baly, *Physikal. Z.*, 1913, **14**, 893). The results were almost identical with those obtained with platinized platinum electrodes.

52. Absorption spectra of colloidal chlorophyll in the presence and absence of CO_2.

Z. H. SIDDIQI *and* M. QURESHI, Hyderabad-Deccan.

Pure specimens of chlorophyll $(a+b)$ have been prepared from spinach, following a modification of Willstatter and Stoll's method. These specimens and a specimen of pure chlorophyll (a), obtained from Prof. Stoll's laboratory at Basle, were used in the preparation of colloidal solutions of chlorophyll. Complete absorption spectra of colloidal chlorophyll in the absence of CO_2 and after treatment with carbon dioxide have been measured with the help of a spectro-photometer of König and Martens' type. A comparison of the absorption curves indicates that CO_2 forms some sort of chemical combination with colloidal chlorophyll.

53. Absorption spectra of cobaltous chloride in ordinary and heavy water.

K. VEERIAH *and* M. QURESHI, Hyderabad-Deccan.

Complete extinction coefficient curves have been obtained for $CoCl_2$ dissolved in H_2O and D_2O respectively. The comparison of the two curves shows that there is no shifting of bands when H_2O is replaced by D_2O. The light absorption in the case of the solution in heavy water is less throughout the whole range of absorption. The difference, however, is not uniform, being greatest in the region of maximum absorption, and least in the region of minimum absorption.

54. Isomeric transformation of anhydrous chromic chloride in ordinary and heavy water.

K. VEERIAH *and* M. QURESHI, Hyderabad-Deccan.

The transformation of anhydrous chromic chloride in ordinary and heavy water has been followed by observing changes in light absorption, and complete extinction coefficient curves in the visible region have been obtained in the case of both the solutions after the attainment of equilibrium, which is reached in $10\frac{1}{2}$ hours in the case of ordinary water and 15 hours in the case of heavy water, the molar strength of the solutions and other factors being the same.

The slowness of the transformation in the case of heavy water supports the view that the transformation of chromic chloride hexahydrate in solution is not a simple isomeric change, but a complex change, in which the isomeric change is preceded by hydrolysis.

The comparison of the extinction coefficient curves shows that there is a slight shifting of the maximum towards longer wavelengths, when H_2O is replaced by D_2O in chromic chloride hexahydrate.

55. The 'light effect' in air under electrical discharge.

S. S. JOSHI *and* B. L. RAO, Benares.

It was observed by Joshi and Deshmukh that the sensitivity of the procedure which sufficed for the determination of the photo-diminution of current in the case of chlorine was found to be quite inadequate when applied to other gases like air, etc. By adopting a special technique developed by them, it was possible to establish the production of the above phenomenon in air both when alone and in the presence of coatings of a number of materials.

The light effect on the discharge current *in air* was investigated in the pressure range 2·5–16·2 cm. Hg. The results showed that *there is a photo-suppression of current at lower pressures* which tends to increase with the magnitude of the applied P.D. and then diminish at higher voltages. *At larger pressures the discharge current tends to increase on irradiation.* As the voltage is increased the magnitude of this increase diminishes and becomes negative; the subsequent changes in this decrease are as described above.

The magnitude of photo-effect in the presence of a coating of potassium chloride was determined in a large number of experiments in which the gas pressure was varied from 0 to 44 cm. Hg. The applied potential difference at any one of the above pressures was varied over a wide range. As a result of several series of experiments, it is concluded that the 'light effect' whether positive or negative tends to decrease rapidly after increasing the gas pressure beyond a certain range. Results were similar with barium chloride.

A comparison of the results of the two series of experiments shows that the presence of potassium chloride tends to make the photo-suppression more pronounced.

56. Studies of the 'light effect' in hydrogen, oxygen and their mixtures.

S. S. JOSHI *and* T. V. CHERIAN, Benares.

The results of the reduction of the discharge current as a result of irradiation in hydrogen are similar to those observed by Joshi and Narasimhan in chlorine but the effect is very much smaller in magnitude except under specially sensitive arrangement and precautions.

The effect has, however, now been observed in pressures from 1 to 25 cm. Hg., the corresponding range over which the potential applied to the discharge tube was 300 to 3,000 volts (r.m.s.). The frequency of the A.C. supply used was 50 cycles per second.

It has been observed that at a constant pressure, the magnitude of the *photo-suppression* increases with the voltage to a maximum; with further increase, however, it tends to diminish. The *photo-suppression* is negligible at very small and large pressures. In a limited range of intermediate pressures, the effect increases with pressure and then diminishes.

Compared with hydrogen, the behaviour of oxygen subjected to discharge and then irradiated was exceedingly peculiar. The '*light effect*' in oxygen is of the same order of magnitude as in hydrogen. In the pressure range 1 to 22 cm. Hg and the same range of voltage as in hydrogen, it was found that at small pressures, the '*light effect*' was negative. At higher pressures, the suppression shows an over-all diminution with an initial (that is, at low potentials) tendency towards a positive effect. This tendency becomes more conspicuous at higher pressures. *At intermediate pressures the gas under light shows both an increase and a subsequent diminution of the current, as the applied voltage is progressively increased. At still higher pressures, there is no photo-suppression but only an increase in conductivity due to light which increases to a maximum followed by decrease.* A further increase in the gas pressure diminishes this increase, and at still higher pressures this effect seems to be absent. It is found from the data of the characteristic curves that the *photo-effect, whether positive or negative, becomes detectable at the threshold potential*; its magnitude (independent of whether it is positive or negative) diminishes by an increase of the voltage beyond a certain value. If the gas used for such an experiment is *pre-subjected* to different durations of discharge at a fixed voltage, the increase of this duration at first increases the effect and then diminishes it. This might be considered to be chiefly an *ageing effect*; it becomes more pronounced if the voltage at which the gas is pre-subjected to discharge is increased.

The results with mixtures of hydrogen and oxygen have hitherto shown only *increase* of conductivity under light.

57. The 'light effect' in sulphur dioxide under electrical discharge.

S. S. Joshi, G. S. Deshmukh, *and* U. S. Dhar, Benares.

The general technique and experimental procedure was similar to that adopted in the study of 'light effect' in other gases studied in these laboratories. The gas was prepared from sodium bisulphite and purified in the usual way, finally by freezing out with liquid air. Presumably, on account of the fact that the dielectric strength of sulphur dioxide is comparatively high, very large potentials were required to start the discharge in sulphur dioxide in the Siemens' tube, although with other gases relatively low pressure were employed, viz. up to about 12 cm. Hg. The gas *shows an unmistakable diminution of the discharge current under irradiation.* Furthermore, the characteristic voltage-current curve at any given pressure of sulphur dioxide under light was always found to be lower than that obtained in the dark.

Interesting results were obtained when the *photo-diminution* was measured at different periods of exposure of sulphur dioxide to electrical discharge at a given initial pressure. The 'light effect' was found to diminish rapidly and finally disappear altogether after a certain progress in the decomposition of the gas. This has been ascribed to the possible influence of the product, viz. free sulphur and sulphur trioxide deposited on the glass walls during decomposition for which evidence has been obtained.

58. Studies on 'light effect' in chlorine: influence of the pre-treatment of the dielectric surfaces by gases under electrical discharge.

S. S. Joshi *and* V. S. Raghavan, Benares.

During the course of over three years' observations of our results of electrical discharges in gases especially chlorine, it was suspected that even a brief use of a discharge tube for a different gas produced appreciable changes in the subsequent behaviour of the discharge tube. The results now reported refer to two discharge tubes designated *A* and *B*. *A* has been in use for almost entire part of the above period for the studies of the photo-suppression in chlorine only. It was subsequently used for but a short period (not exceeding a couple of months) for work with bromine vapour, mixtures of bromine and chlorine, mixtures of hydrogen and bromine and subsequently pure hydrogen. The results with the last gas showed a large positive effect in a series of observations, which was very surprising.

After this, the discharge tube was cleaned and worked for the study of the '*light effect*' in chlorine. It was very interesting and suggestive to observe that both the discharge current and especially the magnitude of the light effect decreased enormously. Careful and repeated cleaning of the ozonizer and purification of the gas produced no sensible increase in either of the above quantities.

Two series of experiments were next carried out under exactly the same conditions of pressure, temperature, applied potential and the purity of the gas, for the discharge tubes A and B; the latter was freshly prepared and cleaned in the usual way before use. On account of the difference in spacing, the significant fields producing the ionization, however, were not the same for A and B. As against the very markedly reduced discharge current and the photo-suppression in A, the results for both the above quantities observed over a wide range of conditions showed high values in agreement with our experience of the behaviour of chlorine under electrical discharges.

It may be mentioned that adopting the technique developed by Joshi and Deshmukh in this laboratory the current in every experiment was measured by two independent methods, viz. by using a sensitive D.C. indicator actuated by (1) a metal oxide rectifier, and (2) a vacuo junction in series with the discharge tube. When the photo-suppression of the current was measured by both these methods at a number of potentials after passing one hour's discharge, under the same conditions of P.D., gas pressure, etc. in A and B, it was found that both the current and the suppression under light were markedly greater in A after than before the discharge. The freshly prepared B, however, did not show any such increase. These results have obviously an important bearing on the ageing phenomenon observed under electrical discharges and their detailed study under different conditions might help in the elucidation of the relevant mechanism.

59. Studies on 'light effect' in bromine vapour subjected to electrical discharge.

S. S. JOSHI *and* S. SIRSIKAR, Benares.

The observations of Joshi and Narsimhan have indicated the existence of a new type of phenomenon, viz. a spontaneous variation (*usually though not invariably diminution*) *of the ionization current on irradiation.* The experiments now reported have extended the occurrence of the effect in bromine vapour over a wide range of conditions. The general arrangement of the apparatus and the experimental procedure was similar to that adopted in the case of chlorine with the difference that in bromine special precautions were found to be necessary in regard to the temperature control.

At a higher temperature, about 75°C., the current diminished immediately on irradiation to an extent which tended to increase with the applied P.D. A series of characteristic voltage-current curves have been obtained in the dark and under irradiation. Over the entire range of the voltages used, the curve due to light lies sensibly below that for the dark reaction, to an extent which is variable with temperature. Presumably, this is on account of an altered population of the bromine molecules (and atoms) present in the discharge space. As is to be anticipated from earlier results in this line from these laboratories the threshold potential for the bromine vapour was greater on irradiation than without it, other conditions being kept unaltered.

60. The 'light effect' in iodine vapour under electrical discharge.

S. S. Joshi *and* Y. D. Kane, Benares.

The present paper reports results on the diminution of the discharge current produced by a given potential applied to a Siemens' type ozonizer, in the annular space of which iodine vapour was introduced from a side bulb kept at a constant temperature.

A circumstance noticed previously in the case of bromine vapour, viz. 'ageing effect' was found to be a very appreciable influence in the case of iodine. The system also showed considerable hysteresis in regard to the current as a function of the applied P.D. These appeared both in the dark and light and rendered difficult the determination of the '*light effect*' on the discharge current.

By using a specially sensitive arrangement for detecting small changes in current, the above effect was observed definitely in the case of iodine vapour after making due allowance for the 'ageing' and 'hysteresis' effects. As in the case of bromine vapour the '*light effect*' is distinctly greater at higher temperatures due to increased concentrations of iodine in the ionization space; the effect also increases by increasing the applied voltage.

61. Further investigation of 'light effect' in iodine under electrical discharge.

S. S. Joshi *and* N. M. Bhatt, Benares.

That the behaviour of iodine under the discharge and irradiation would present a series of peculiar features dependent upon the operation conditions was a foregone conclusion from a consideration of the results obtained already in regard to the 'ageing' effect. It is found that θ the '*light effect' in iodine is both positive and negative, depending upon the condition and the magnitude of the applied potential.* The generality of the sequence of changes will be indicated by results of the following typical series of observations.

At about 55°C. and about 150 volts (r.m.s.), the 'light effect' is not sensible within the limitations of the available instruments. With rise to 200 volts (r.m.s.) there is an enormous increase of current due to irradiation, the actual value for θ, the light effect, being 41 divisions, positive. By increasing the voltage to 220, θ changes sharply from the above value to 7 negative. Further increase of voltage increases the photo-diminution to a maximum; it then diminishes to zero as the applied P.D. reaches about 820 volts (r.m.s.). A precisely similar sequence of changes in respect of θ was observed at the lower temperatures. At much higher temperatures, the only difference observed was that θ was not abolished at higher potentials as at 55°C. The initial photo-increase and subsequent photo-diminution, both on a large scale, being once more observed.

The system showed 'hysteresis', i.e. the photo-diminutions with decrease in the potential were greater than those when it was increased progressively.

62. The 'light effect' in hydrochloric acid gas under electrical discharge.

S. S. Joshi *and* K. M. Ramamurthi, Benares.

The '*light effect*' in hydrochloric acid gas is of such a small magnitude, that ordinary indicators fail to reveal it. An ingenious method devised by Deshmukh, viz. simultaneous measurements by rectification with a metal oxide and a vacuo-junction has been used.

The behaviour of a purified sample of the gas has been studied at various pressures ranging from 0·3–51 cm. Hg.; the applied potential was varied from 200–7,000 volts, the frequency of the A.C. supply being kept at 50 cycles per second. As observed in the case of other gases in these laboratories, '*the light effect*' tends to increase in magnitude by increasing the secondary potential and by diminishing the pressure. At low pressures, however, it diminishes. This is in agreement with the fact that the characteristic potential-current curves for various pressures corresponding to irradiation lie below those obtained for the dark reactions.

Interesting results have been obtained in several series of experiments at various pressures when the magnitude of the '*light effect*' was determined in a series of observations, in which the applied potential was increased progressively. The gas was then exposed to discharge at the maximum potential. It was now found that if without a discontinuation of the discharge, the '*light effect*' was determined at the same potentials, the photo-suppression is usually found to increase appreciably.

63. Studies of the 'light effect' in chlorine. Part I. The anomalous behaviour of the oxide rectifier in discharges with high pressures of chlorine.

S. S. Joshi *and* V. S. Raghavan, Benares.

For the studies in the '*light effect*' in chlorine under electrical discharge, the chief result of increasing the pressure of chlorine is found to be to reduce the photo-diminution of current. It was, however, remarkable to see that in this high pressure region, chlorine admixed with bromine showed a very much greater '*light effect*' than pure chlorine alone. At low pressures, however, the '*light effect*' was appreciably reduced by substituting bromine, or air, for a part of chlorine.

Interesting results were obtained when the discharge current was measured by using (i) an oxide rectifier, and (ii) a vacuo-junction, following the technique developed by Joshi and Deshmukh. It was observed that, in the dark, the former gave apparently *negative* deflections at small potentials and high pressures of the gas. On irradiation, this deflection continued to be negative but decreased in magnitude. The familiar photo-suppression was observed at higher voltages. At an intermediate voltage the system showed an apparent 'nul-point'. When, however, the observations of the current at the same potentials were repeated with the vacuo-junction, as was to be expected, the current showed mere increase in values and their increasing suppression due to light as the applied potential was increased. It was thought desirable, therefore, to carry out detailed measurements by using both the methods, especially under those conditions where (1) gave apparently negative readings. It is seen that this anomaly increases both in magnitude and also in regard to the range of the applied potential by increasing the gas pressure. Whilst the '*light effect*' as such obtains over the entire region, the anomalous, i.e. the apparently negative readings, are considered to indicate a deviation from the normal of the rectification performance of the metal oxide due perhaps to the 'upper partials' and the 'wave form' under those conditions.

64. Studies of the 'light effect' in chlorine. Part II. Influence of ageing and hysteresis.

S. S. Joshi *and* V. S. Raghavan, Benares.

The present paper reports results of studies in detail in the case of chlorine, whose sensitivity in regard to the observed photo-variation of the current under discharge has been found to be outstanding. We have now seen as a result of a scrutiny of a large number of characteristic curves that usually, if not invariably, ***hysteresis*** obtains, especially at high voltages, i.e. sensibly larger currents are observed in diminishing progressively the applied potential than during its increase. It was instructive to observe that the same factor is noticeable in the production of θ, the photo-diminution of the current. Several series of experiments were carried out at various values for the applied potential and the gas pressure in each of which θ was measured as a function of the applied potential increased progressively to a maximum; the voltage was then reduced to the initial value and θ re-determined as previously; it has been now observed that almost always θ shows a greater value in the latter than in the previous series. The enchancement of θ in this way, however, diminishes as such repetitions are increased in number.

Similarly, it is also very interesting to report at this stage the results observed in regard to the above influence determined in a series of comparative measurements for two discharge tubes described in the previous abstract. It was observed that the increase of θ as a result of 'ageing', i.e. due to previous exposures to the discharge was very appreciably larger in the case of a discharge tube which had been rendered comparatively insensitive in regard to the '*light effect*', than a fresh one which showed the familiar behaviour on irradiation.

65. Studies of the 'light effect' in gases under electrical discharge. Part III. Certain apparently anomalous results, showing a photo-increase of current in bromine, chlorine and hydrogen.

S. S. JOSHI *and* V. S. RAGHAVAN, Benares.

The present paper reports the observations of some apparently anomalous results which were made during the last three years on the '*light effect*'.

At a pressure of about 5 cm. Hg, bromine vapour showed a photo-increase at low potentials and the familiar suppression at higher potentials. This has now been observed by Joshi and Cheryan in the case of oxygen and by Joshi and Bhatt with iodine vapour. A similar *photo-increase* was observed in one isolated series of observations by Kuppuswami in these laboratories in the case of chlorine. There was a small but perceptible photo-increase at low potentials which changed to negative as the last quantity was increased appreciably.

The above discharge tube was then filled with purified hydrogen. It showed but little '*light effect*' in a large number of experiments. The sample of hydrogen at the end of these experiments was then given a continuous exposure to the discharge for over 3 hours. This resulted in rendering the system active, as was observed in the case of HCl, I_2, O_2, and Cl_2. The gas now showed a slight photo-increase for small P.D. and a photo-decrease at larger P.D.'s. When the gas was given a continuous 6 hours' exposure to the discharge, the magnitude of the initial photo-increase became very large (about 20 divisions); as in the previous case, it changed to suppression on further increasing the P.D.

A series of experiments was now carried out in which the initial photo-increase due to a constant voltage was measured under a filament light of constant intensity; it was passed through different light filters. The results obtained show a marked dependence of the photo change on the light frequency.

66. Studies of the 'light effect' in chlorine. Part V. Further studies of the anomalous behaviour of the metal oxide rectifier.

S. S. JOSHI *and* V. S. RAGHAVAN, Benares.

The results reported here not only emphasize the disparity of performance between the two indicators, metal oxide and vacuo-junction rectifiers, but have a marked bearing on the significance and mechanism on the '*light effect*'.

Consider the ratio I/I_s, where I_s is the current recorded by an indicator *with a shunt* (in this case a decoupling resistance of negligible inductance and capacity) and I is the current in the absence of any shunt. Obviously, I/I_s for a given current indicator must remain constant whatever be its value in the absence of a shunt. This has always been observed in the case of currents measured with the vacuo-junction. When, however, the oxide rectifier is used the above ratio differs markedly when the current is measured under irradiation from that measured in the dark. Furthermore, the ratio decreases rapidly with increasing the discharge current under light. In the dark, the ratio remains constant and independent of the magnitude of the current flowing through the system. This ratio for the dark, varies sensibly from gas to gas under comparable conditions. This quantity is, however, remarkably constant for different gases, or, for light and darkness, in the case of rectification by use of the vacuo-junction. These results are now correlated with the characteristic behaviour (as in a thermionic valve) of the oxide, functioning as an A.C. rectifier and the change induced by irradiation in the input A.C.

The marked difference in the two discharge tubes, (*a*) used for 3 years, and the other (*b*) freshly made, has been mentioned in Parts II and IV. (*a*) was rendered insensitive and showed but a small light effect; this last increased on prolonged activation under the discharge. Now, it was found that the value for the above ratio, I/I_s for (*a*) was markedly lower than that for (*b*) in the dark and that it approached the latter on activation under the discharge.

67. Studies of the 'light effect' in iodine vapour in the presence of potassium iodide and potassium chloride.

S. S. Joshi *and* K. N. Murthy, Benares.

A comprehensive investigation using a large number of inorganic and certain type of organic substances deposited in the form of coats on the electrodes is already in progress. The present paper is, however, restricted to the use of a coat of a mixture of potassium iodide, potassium chloride and iodine, since the results have been of outstanding interest. It has been observed that the *discharge in the iodine vapour in the presence of the above material shows on irradiation a remarkably large increase*, which increases to a certain maximum and then diminishes to almost zero with further increase of the potential. At the last, i.e. insensitive stage, on mere irradiation with discharge for an appreciable period, the system becomes active and once again shows the large photo-increase up to another maximum and subsequent decrease, but on a larger scale than in the previous sample. After reaching the inactive, i.e. the insensitive stage at the minimum, once more, on activation by combined discharge and irradiation, the entire sequence of changes can be reproduced but on a smaller scale, which diminishes with the next repetition. Usually, almost a permanent insensitivity is produced after a few such repetitions and the material cannot be 'activated' by the above means and has to be replaced. A reference to the literature shows that no such phenomenon is on record.

It is instructive to point out that the characteristic potential-current curves corresponding to light lie appreciably above those for the dark in these experiments when a photo-increase was obtained.

Observation of the change in conductivity under light investigated over a long and continuous discharge also shows a periodic change, which changes its sign, i.e. shows diminution of current due to light.

It was found that the system shows considerable hysteresis when the applied voltage is increased up to a certain convenient maximum and then decreased to the initial position, to be increased once again and so on.

68. Studies in the behaviour of 'quenched' active nitrogen.

S. S. Joshi and N. Subramanian, Benares.

The possibility of the existence of a '*dark*' modification of active nitrogen was suspected, ever since its discovery by Lord Rayleigh and Lewis. The experiments described in the present paper, were carried out in order to investigate under what conditions the activity of '*quenched active nitrogen*' might persist.

Active nitrogen prepared by a condensed spark-discharge was '*quenched*' by passing through a spiral heated to the requisite temperature. The '*quenched*' gas was then led into an observation chamber in which a carefully cleaned glass plate was suspended near the inlet for the gas. The material to be examined for sensitivity towards the '*quenched*' gas was deposited in the form of a thin coat on this plate by evaporating off some solution. It was observed that in the case of phosphorus, the observation-tube showed a feeble but definite luminosity, which just out-lasted the discontinuation of the discharge. That this result cannot be ascribed to the heated nitrogen was shown by failure to get any results, when only, heated nitrogen, without activation by electrical discharge, was employed. It would appear that induction of luminescence by the '*quenched*' gas depends upon the specific chemical nature of the material employed. The action bears no relationship to sensitivity towards 'active nitrogen'. For example, iodine which is conspicuous for its glow induced by active nitrogen, shows a faint luminescence, only at high pressures of the '*quenched*' gas. Lithium phosphate, which luminesces markedly under active nitrogen, did not show any glow after quenching.

Barium sulphite, sulphate and borate, and lithium benzoate showed very feeble luminosity. Films of freshly deposited sodium and potassium were found to be insensitive.

Interesting results were obtained when films of phosphorus were used as detectors. The glow, though feeble when the temperature is sufficiently high for '*quenching*', is marked up to a certain maximum limit, after which there is absolutely no glow. The activity of the quenched nitrogen seems to have been completely destroyed above this temperature.

69. The studies of the current 'ageing' in iodine under electrical discharge.

S. S. Joshi *and* N. M. Bhatt, Benares.

The occurrence af 'ageing', that is, a time variation of the discharge current produced when iodine vapour is subjected to an electrical discharge at a constant potential applied to Siemens' type discharge tube, has been observed by Joshi and Deshmukh and subsequently by Joshi and Kane in these laboratories, in connection with their work on the photo-variation of the discharge current in iodine. As this 'ageing' effect was found to be almost of the same order of magnitude as the current variation produced by irradiation, it was instructive to investigate, in some detail, the various factors on which it depends, so as to discriminate the same from the light effect, observed for the first time in these laboratories. As a result of several series of experiments in which the discharge current produced due to the application of a series of potentials at various temperatures, it was observed that the behaviour of iodine vapour suggests the existence of three types of action *A*, *B*, *C*. *A* obtains under the discharges at ordinary temperatures and is characterized by the occurrence of a number of discontinuities on the current-time curves; the corresponding range of potentials was insufficient to produce a perceptible glow. During *B*, the discharge current shows markedly rapid fluctuations in the current and an overall increased conductivity. The corresponding glow due to the discharge just flickers, that is, shows more unsteady and shifting local brushes. In C the current shows a minimum of 'ageing', that is, keeps sensibly steady over a long length of time. The corresponding glow due to the discharge is both bright and uniformly distributed throughout the annular space. It has been found that the transition from $A \rightarrow B \rightarrow C$ is effected by an appropriate rise of temperature and voltage. Thus, for example, at ordinary temperatures when investigated for considerably long durations of exposures to discharge within a fairly wide range of applied voltages, it was found that the A persisted. It changed into B under discharges at higher temperatures, viz. 48° to 80°. The change was markedly quicker, higher the temperature at the potential applied. The transformation of B into C would appear to be mainly a thermal reaction, though perhaps accelerated by the magnitude of the applied potential. Thus for example, it was interesting to observe that a reversal $C \rightarrow A$ could be produced by only momentarily cooling the system. This change also was not sensibly affected by the value of discharge potential. Similarly, it was observed that the progress from $B \rightarrow C$ was practically independent of the above factor.

It is considered that (1) condition in A shows breaks perhaps due to the rupture and the reformation under the discharge of iodine adsorbed by glass. This process becomes more conspicuous in B and reaches a certain definite stage of completion in C, where the flow is well developed and uniform; though a minimum 'ageing' effect is still detectible in C and may be attributed to incipient interaction between glass and iodine under the discharge as is suggested by Lendeking.

70. The 'light effect' in nitrogen peroxide subjected to electrical discharge.

S. S. Joshi *and* K. S. Visvanathan, Benares.

As in the case of the iodine vapour and oxygen, the 'light effect' in nitrogen peroxide was found to be both positive and negative depending upon the conditions. Before the threshold potential, there was no '*light effect*'. It amounted to upwards of 4% of the current at the threshold potential and tended to increase by increasing the applied potential and the intensity of irradiation. There was no '*light effect*' on large pressures (above 40 cm. Hg).

71. Hysteresis in sorption. VIII. Scanning of the hysteresis loop. Titania gel-carbon tetrachloride system.

K. Subba Rao, Bangalore.

Further work on scanning of the hysteresis loop in sorption (Rao, *Jour. Phys. Chem.*, 1941, **45**, 506) affords additional evidence in support of the cavity concept as a general explanation of hysteresis in sorption.

With a McBain-Bakr quartz fibre spring balance a series of sorptions and desorptions of carbon tetrachloride at 30°C. on activated titania gel has been studied and it has yielded a permanent and reproducible hysteresis loop. The loop has been scanned by traversing it from various intermediate points on the sorption and desorption curves. If desorption is effected from any point on the main sorption curve, the hysteresis loop is crossed till the main desorption curve is reached. If, on the other hand, sorption is effected from any point on the main desorption curve, the main sorption curve is not reached, but a separate curve is traced till the peak of the hysteresis loop is reached. These interesting characteristics are of a general nature. They are dependent solely on the shape and size of the cavities in the porous adsorbent and are independent of the nature of the adsorbent and adsorbate.

72. Hysteresis in sorption. IX. Effect of temperature on the hysteresis loop. Silica gel-water system.

K. SUBBA RAO, Bangalore.

With the aid of a quartz fibre spring balance, sorption and desorption of water vapour at 30°C., 35°C. and 40°C. on silica gel activated at 450°C. have been studied. The sorptive capacities of the gel are plotted against the corresponding pressures. The gel exhibits hysteresis effect at all the three temperatures. The shape and size of the three hysteresis loops are identical. With increase of temperature, a slight decrease in the sorptive capacities of the gel at saturation pressure is noticeable. The volumes of water held per 100 gms. of the activated gel at 30°C., 35°C. and 40°C. are 27·7 c.c., 27·4 c.c. and 27·0 c.c. respectively. These observations are in accordance with the cavity concept.

73. Hysteresis in sorption. X. Open pore volume in relation to particle radius.

K. SUBBA RAO *and* V. R. THIRUVENKATACHAR, Bangalore.

Unlike gels of titania, silica and alumina; ferric oxide gel has shown a unique behaviour of a continuous diminution in total capillary volume on successive sorption and desorption (Rao, *Jour. Phys. Chem.*, 1941, **45**, 522). This behaviour has been explained on the basis of the coalescence of the particles of ferric oxide gel. The mechanism of coalescence has received mathematical evidence by the calculation of total cavity volume in relation to particle radius, assuming a porous system of particles of equi-radius. Calculation of total open pore volume in relation to particle radius has been presented in this paper. Just like the total cavity volume, the total open pore volume (V_p) also decreases as the particle radius (r) increases $\left[V_p \propto \left(r_0^3 - 2r^3 \right) \right]$. The total capillary volume being made up of the cavity as well as the open pore volumes, therefore, decreases as the particle radius increases. The ratio of the open pore volume to cavity volume is found to increase with increase in size of particles. The ratio for particle radius tending to zero is nearly half of the ratio for particle radius, when there is one cavity with four open pores.

•74. Soil structure in relation to hysteresis in sorption.

K. SUBBA RAO *and* B. SANJEEVA RAO, Bangalore.

The problem of the retention of moisture by soils has been investigated by a study of the sorption hysteresis. By employing the McBain-Bakr quartz fibre spring balance, sorption and desorption of water vapour at 30°C. on black cotton soil and red laterite soil activated at 80°C. for 6 hours have been studied. The sorptive capacity of black cotton soil at saturation pressure is more than twice that of red laterite soil. At lower humidities this difference in sorptive capacities is more marked. Both the soils exhibit hysteresis effect. The area of the hysteresis loop in black cotton soil-water system is greater than that of the loop in red laterite soil-water system. The tail-end of the hysteresis loop with red laterite soil terminates at a relative humidity of 0·5 whereas with black cotton soil it extends up to a relative humidity of 0·2.

75. Adsorption and display of colours.

K. SUBBA RAO, Bangalore.

When activated alumina gel is dropped into a mixture of benzene and carbon tetrachloride, the white gel becomes jet black; whereas with either benzene or carbon tetrachloride the gel develops no such colour. This extremely interesting phenomenon is of a general character. Sulphate in alumina has an important rôle in this effect. With sulphate in alumina it would always show the colour effect and without it there would be no trace of the black colour. In place of carbon tetrachloride several halogen derivatives have been used. The effect is always produced in a mixture containing an aromatic nucleus and a halogen derivative. When the blackened gel is dropped into water, the colour disappears. This is due to the preferential adsorption of water by the gel surface.

The mechanism of the development of the black colour is probably the case of the formation of an adsorption complex and a precursor to the well-known Friedal and Craft's reactions.

76. The surface behaviour of casein.

G. N. Subba Rao, K. S. Gururaja Doss, *and* B. Sanjiva Rao, Bangalore.

Casein (Hammersten) was spread from its aqueous solutions on substrates of different pH. It was found to have a limiting area of 11,900 sq. cms. per mg. at $p\text{H} = 1{\cdot}2$. The ribbon method of Langmuir (*Jour. Am. Chem. Soc.*, 1938, **60**, 2804) was found to be superior to the dropping technique. Addition of amyl alcohol diminished the spreading. Denaturation by alcohol diminished the spreading. Presence of salts in the substrate did not sensibly affect the limiting area. An isodisperse fraction, soluble in alcohol, was prepared and its spreading properties studied. Its limiting area was found to be not sensibly different from that of the original material. The solutions of the two samples of the protein were found to exhibit variation of surface tension with time. The variation was studied by the Adam trough technique. The rate of accumulation was studied by the trough technique, developed in this laboratory (*Proc. Ind. Acad. Sci.*, 1936, **4**, 97). The accumulation was rapid in the beginning and then slowed down. The compressed film was found to exhibit an increase of surface tension with time.

77. Opacity measurements during the setting of zirconium hydroxide gel.

Mata Prasad *and* N. A. Padwal, Bombay.

The opacity measurements were made by the apparatus designed by Prasad and Gogate. The gels were prepared by the method of Prakash (*Jour. Ind. Chem. Soc.*, 1932, **9**, 193). The gel-forming mixture is transparent in the beginning and becomes opaque during setting. The rate of change of opacity increases with an increase in the amount of sodium acetate and zirconium nitrate and with the addition of alcohol to the gel-forming mixture. The addition of HCl and acetic acid, however, decreases the rate of change of opacity. A distinct change in the final value of opacity takes place with a variation in the factors mentioned above.

78. Opacity measurements during the setting of gels of thorium and cerium phosphate.

Mata Prasad *and* S. Guruswamy, Bombay.

The opacity measurements were made by the apparatus recently devised by Prasad and Gogate. It has been found that this apparatus yields extremely repeatable results under constant conditions. Thorium phosphate gels were prepared from thorium nitrate, potassium phosphate and phosphoric acid. It has been found that during the setting of these gels, opacity decreases with time and ultimately clear gels are obtained. The rate of change of opacity increases with an increase in the amount of phosphoric acid, HCl and thorium nitrate in the gel-forming mixture but it decreases with the addition of methyl and ethyl alcohols.

Cerium phosphate gels were prepared from cerium nitrate and potassium phosphate. The gels were turbid in the beginning but later they became clear. The rate of change of opacity decreases with increasing amounts of cerium nitrate and potassium phosphate in the gel-forming mixture.

There is a distinct change in the final value of opacity in the gels of cerium phosphate and under certain conditions in the case of thorium phosphate gels. This observation is considered to be of great theoretical interest.

79. Studies on the adsorption of alkaloids by silica gel.

B. P. Sarkar *and* P. B. Ganguly, Patna.

The adsorption of several alkaloids, viz. morphine, brucine, nicotine, cinchonidine, quinine, etc., by silica gel has been investigated. The gel was activated by drawing a current of dry and carbon-dioxide free air through it while at 250–300°C. Measurements were made in alcoholic solutions. As silica gel also adsorbs alcohol, allowance was made of this effect in calculating the amounts of adsorption. For estimation of brucine, cinchonidine and caffeine, the iodometric method of Prescott and Gordon was used; for the estimation of morphine, quinine and nicotine, conductometric titration with silico-tungstic acid was followed. Definite adsorption was found in all the cases which was in the following order: nicotine > quinine > brucine > cinchonidine > morphine > caffeine. Further work to examine if the adsorption bears any relationship to group structure is in progress.

80. Studies in chemisorption of oxygen on charcoal: experiments with oxygen, nitric oxide and nitrogen tetroxide.

M. S. Shah *and* B. K. Trivedi, Ahmedabad.

In continuation of the previous work the authors have carried out a quantitative investigation on the behaviour of sugar charcoal exhausted at 900° towards oxygen, nitric oxide and nitrogen tetroxide at various temperatures between 0° and 300°. At each temperature, the charcoal containing chemisorbed oxygen with or without retained oxides of nitrogen in vacuo has been examined by (i) 'heat treatment' in successive stages up to 900°, and (ii) 'water treatment' first with ice cold water and then with hot water. The analysis of the gas evolved in (i) revealed the extent of chemisorption of oxygen and retention of oxides of nitrogen on charcoal in vacuo at different temperatures and that of the cold and hot aqueous extracts in (ii) showed the amounts of chemisorbed oxygen and retained oxides of nitrogen giving rise to oxalic acid and nitrous and nitric acids respectively.

The results, on the whole, show that the state of chemisorbed oxygen on charcoal is affected by a rise in temperature, treatment with water, and when surrounded by (i) oxygen, (ii) nitric oxide, and (iii) nitrogen tetroxide. The retained nitric oxide in experiments with nitric oxide is *neither* chemisorbed like oxygen nor is under the influence of chemisorbed oxygen on charcoal but exists as condensed N_2O_4 (or N_2O_3, i.e. along with nitric oxide) in the adsorbed state on charcoal, an observation confirmed from the behaviour of charcoal towards nitrogen tetroxide. In the interaction between charcoal and nitric oxide at low temperatures the charcoal surface starts and catalyses the auto-oxidation of nitric oxide, i.e. the formation of nitrogen tetroxide with the liberation of nitrogen, and the nitrogen tetroxide so formed then interacts with charcoal leading to the chemisorption of oxygen and production of carbon dioxide and nitrogen through the chemisorbed oxygen, the behaviour of charcoal with the chemisorbed oxygen and retained oxides of nitrogen in vacuo derived from both the nitric oxide and nitrogen tetroxide experiments being of the same type in 'heat treatment' and 'water treatment', except in the sense that the chemisorption of oxygen and retention of nitrogen tetroxide proceed more pronouncedly in the nitrogen tetroxide experiments than in the nitric oxide experiments.

81. Studies in adsorption.

M. D. Avasare *and* (Miss) K. K. Paralikar, Baroda.

A review of the literature on adsorptions from solutions shows lack of proper attention being paid to the time factor. The published data cover periods of contact between the adsorbent and the adsorbate ranging from 15 or 30 minutes to 24 hours or even several days in others. The observed data, therefore, includes both adsorption and absorption effects. In the adsorption of iodine, from aqueous solutions by sugar charcoal, for instance, it has been observed that the charcoal goes on taking up iodine for several hours. The observed effect, therefore, cannot be regarded solely due to adsorption. In the present investigation attempts have been made to evaluate the purely adsorption effect by studying changes in concentration with time when solutions of iodine, etc., in different solvents are kept in contact with activated sugar charcoal and the results thus obtained are discussed in the light of the established theories of adsorption.

82. Variation of the cataphoretic velocity of colloidal particles during aggregation.

S. G. Chaudhury *and* M. K. Indra, Calcutta.

The cataphoretic velocity of a colloid is shown to be a property— which in some essential respects is similar to that of the coalescence of the colloidal particles in presence of electrolytes. It is, therefore, natural that conditions which govern the rate of coalescence of the colloidal particles would also similarly govern the rate of change of the cataphoretic velocity of the colloidal particles during coagulation. The present paper deals with only one single aspect of the question and shows that as purity of the sol (here copper ferrocyanide) increases, the time effect with polyvalent precipitating ion tends to disappear and the rate of diminution appears to be the same when potassium ferrocyanide is in excess.

83. Charge and stability of colloids. Part V. Potentiometric titration of chromium hydroxide sol.

B. P. Yadava, Lucknow.

In this paper the potentiometric titrations of chromium hydroxide sol prepared from chromium chloride and ammonia have been studied. It has been found that when the sol is impure the titrations with KNO_3, K_2SO_4, and K-citrate liberate a larger quantity of chlorine ions than the quantity of the coagulating electrolyte added, (the coagulating electrolyte being expressed in terms of the equivalent amount of chlorine) but when the same sol is purified by dialysis the quantity of chlorine set free by the addition of the same coagulating electrolytes is less than the amount of electrolytes added.

84. Charge and stability of colloids. Part VI. Study of ionic antagonism by potentiometric titration method.

B. P. YADAVA, Lucknow.

Coagulation of negatively charged manganese dioxide sol has been studied on the addition of KCl, $BaCl_2$, and mixtures of these, and potentiometrically the quantity of chlorine adsorbed at various stages of the addition of electrolytes has been determined. On comparing the amount of chlorine that is actually adsorbed with that which should have been adsorbed taking the total adsorption when $N/10$ KCl and $N/100$ $BaCl_2$ are added singly, we find that whenever a mixture is present the quantity of Cl ions adsorbed which carries the same charge as the colloid itself is considerably increased. This appears to be a corroboration of the hypothesis that ionic antagonism is due to the adsorption of the ions carrying the same charge.

85. Charge and stability of colloids. Part VII. A possible explanation of Hardy-Schulze law.

B. P. YADAVA *and* A. C. CHATTERJI, Lucknow.

In a number of experiments carried out in this laboratory it has been attempted to correlate stability of colloids with the displacement of counter ions. In a series of results obtained it has been found out that to produce displacement of chlorine ions from a ferric hydroxide sol prepared from ferric chloride and ammonia, it is necessary to add a very large quantity of the univalent electrolyte to displace a quantity of chlorine ions sufficient to bring about coagulation, whereas in the case of sulphate and citrate ions the same order of displacement of chlorine ions is brought about by much smaller amounts of the electrolytes. This seems to suggest an explanation for the relative coagulating powers of ions of different valencies.

86. Influence of non-electrolytes on the size frequency of the particles of the gelatin protected emulsions. Part I. Sugars.

C. S. NARWANI *and* T. C. PARAKH, Karachi.

A new method for determining the size-frequency curve has been adopted in this work; the time accumulation curve was plotted by measuring the change in the transparency of the cream zone of the transparent emulsions with the time by means of a photo-electric cell.

The size frequency curve has been determined for the transparent emulsions of amylacetate in 1% gelatin-water-glycerol sols in presence of 1–5 m. moles percentages of (i) glucose, (ii) galactose, (iii) fructose, (iv) sucrose, (v) lactose. The change in the viscosities of the continuous phase, and the interfacial tensions between the continuous and the disperse phase with the addition of the above sugars have been studied experimentally and the influences of these changes compared with those on the stability of the emulsions as determined from the size frequency.

It has been concluded from the results that the sugars increase the stability of the emulsions in the order sucrose$>$galactose$>$glucose$>$lactose while fructose decreases it.

87. State of combination of chlorine in hydrous alumina sols.

N. P. DATTA, Calcutta.

Sols of hydrous alumina having specific conductivity from $1{\cdot}9 \times 10^{-5}$ to $7{\cdot}06 \times 10^{-5}$ mhos. have been prepared by dialysis and electrodialysis.

Sol *A* is of low *p*H (4·73) and high specific conductivity ($1{\cdot}9 \times 10^{-5}$ mhos.) whereas sols *B* and *C* are of high *p*H (6·42 and 6·51 respectively) and low specific conductivity ($8{\cdot}8 \times 10^{-6}$ and $7{\cdot}06 \times 10^{-6}$ mhos. respectively). They have been titrated conductometrically and potentiometrically with silver acetate, nitrate and sulphate. Conductometric titration of sol *A* gives an amount of chlorine which is very nearly equal to the free chlorine determined from the e.m.f. of the Ag/AgCl electrodes but is somewhat smaller than the total chlorine determined after solution of the sol in nitric acid. In the case of sols *B* and *C*, however, chlorine obtained by conductometric titration is much smaller than either the free chlorine or the total chlorine content. The amount of chlorine which react with silver sols as determined by conductometric titration of *B* and *C* depends on the anion and is in the order sulphate$<$nitrate$<$acetate.

88. Opacity changes in colloids subjected to coagulations by exposure to high frequency oscillations.

S. S. Joshi *and* N. Subramaniam, Benares.

Recent works in this laboratory have shown that practically all the characteristic features of electrolytic coagulations can be reproduced in changes produced under high frequency exposures. Such results are in a considerable measure free of certain factors involved in electrolytic coagulations, which it is impossible to evaluate or to discriminate adequately.

The coagulation-time curves due to such apparently different means of producing coagulation have been found to be similar. The results obtained for the variation of opacity of colloids due to high frequency oscillations, also show that an increase in the opacity cannot be regarded as a quantitative measure of the corresponding degree of coagulation, as has been tacitly assumed up till now. A number of these coagulation-time curves also show an initial and a short-lived diminution of opacity, followed by a rise. It is significant to recall in this connection the observation made by Joshi and co-workers that usually, though not invariably, there is an initial fall of viscosity followed by rise. The initial fall has been attributed to various factors, such as adsorption of like ions, etc. Apparently, this is a stabilizing or a de-coagulating circumstance. This would now appear to be also the case under H.F. which are known to exert a dispersing and therefore, a stabilizing action under certain conditions, though no direct possibility of adsorption of part of the coagulant can be entertained.

89. Variation of viscosity of colloids by exposure to high frequency oscillations.

S. S. Banerjee *and* V. S. Raghavan, Benares.

The behaviour of a number of colloids in respect of change of viscosity was examined previously, when exposed to emissions from a powerful condensed spark discharge. The present paper embodies the results of using oscillations of definite wavelengths, viz. 3·66, 4·6, 6 and 80 metres.

In agreement with the results of Joshi and co-workers, it has been shown that the viscosity of the coagulating system varied *discontinuously* with respect to time or '*zonally*', especially when the coagulations were *slow*. They also showed an initial *diminution* of viscosity.

Joshi and Iyengar have explained the discontinuities on the viscosity-time curves by assuming that micellar conglomerates, produced by coagulation, might build up to a certain stage and then break down due to instabilization induced by a number of factors, and then with the reverse change and so on, repeatedly until coagulation changes into flocculation, and this may be the source of the 'zonal effect' found to be generally characteristic of all *slow* coagulations.

90. The rôle of the specific surface in determining the base exchange capacity of subfractions of hydrogen clays.*

J. N. MUKHERJEE, R. P. MITRA. *and* K. C. GHOSH, Calcutta,

Hydrogen clays prepared from five subfractions of the entire clay fraction of an acid soil from the Government Farm at Latekujan, Assam, have approximately the same chemical composition and apparent density in toluene. Their titration curves with bases have also the same form. The curves reveal a weak dibasic acid character. The base exchange capacity (b.e.c.) per gramme calculated at the second inflexion (T_2) is nearly twice the b.e.c. at the first inflexion (T_1) with the exception of one subfraction which gives the ratio 4. Both T_2 and T_1 increase with diminishing particle size except for the fraction which has the highest T_2. The three finest fractions have the same specific surface calculated from the amount of methylene blue adsorbed per gramme. The two coarser fractions have much smaller specific surfaces. With the exception of the above subfraction, the b.e.c. calculated per square metre of the surface is practically constant.

91. Interaction of silicic acid sol with acids.*

B. CHATTERJEE, Calcutta.

A smaller lowering of *p*H is observed in the case of an electrodialyzed silicic acid sol on the gradual addition of oxalic, phosphoric and acetic acids than when those acids are added to a hydrochloric acid of nearly the same *p*H as the sol. When hydrochloric acid is gradually added to both of these solutions the lowering of *p*H is almost the same in either case. This observation indicates that the greater buffer action of the sol against oxalic, phosphoric and acetic acids is not due to a greater suppression in the degree of dissociation of silicic acid but arises from an adsorption of these acids by colloidal particles of silicic acid.

92. Back titration of silicic acid sols.*

J. N. MUKHERJEE, B. CHATTERJEE, *and* A. SEN, Calcutta.

The two titration curves, obtained on titrating an electrodialyzed silicic acid sol with KOH up to *p*H 12·0 and then back titrating the mixture with HCl, are almost similar in nature beyond the inflexion point in the direct titration curve. The back titration curve shows a stronger buffering. The total acids calculated at this inflexion point in the direct and back titration curves are respectively $56{\cdot}0 \times 10^{-5}N$ and $64{\cdot}0 \times 10^{-5}N$ and the *p*H values 10·45 and 10·05 respectively. It has been suggested that the widely divergent values of the dissociation constants of silicic acid, which have mostly been determined by titrating sodium silicate solutions with acids (equivalent to the back titration reported above) result from the use of sodium silicate solutions of different concentrations.

93. An equation for the percolation of water through sodium soils.

M. R. NAYAR *and* K. P. SHUKLA, Lucknow.

It is well known that sodium soils are the most impermeable to water. An attempt has been made to study quantitatively the effect of varying

* The work has been carried out under a scheme of research financed by the Imperial Council of Agricultural Research, India.

amounts of exchangeable sodium on pure Ca soils. It has been found that the permeability of sodium soils depends on three main factors: (i) the degree of saturation of soil complex with respect to Na^+ ion, (ii) the clay content of the soil, and (iii) the base exchange capacity of the soil.

The rate of percolation of water through different grades of sodium soils is governed by the formula first enunciated by A. E. Harris, namely:

$$Y = ae^{-bs} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Where Y = rate of percolation of water.

$$s = \frac{\text{Exchangeable } Na^+}{\text{Base exchange capacity}} \times 100.$$

and a and b are constants, characteristic of each soil.

The constant a has been found to depend upon the clay content, and as a result of experiments with about fifteen soils it has been shown that the following equation holds good:

$$a = \frac{k_1}{\log c},$$

where c is the clay content and k_1 is equal to 0·25 (approx.) for all soils examined. Similarly, the constant b varies directly as the base exchange capacity of the soil, that is, $b = k_2 B$ where B is the base exchange capacity and $k_2 = 0{\cdot}0018$ (nearly).

Substituting for a and b in Harris's equation we get the final relation as:

$$Y = \frac{0{\cdot}25}{\log c} e^{-0{\cdot}18\,(Na^+)} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where (Na^+) = exchangeable sodium in mgm. equiv.

94. An equation for base exchange in soils.

M. R. NAYAR *and* K. P. SHUKLA, Lucknow.

In connection with the adsorption experiments described in another paper we found that in the reversible exchange reaction:

$$CaZ + Na_2CO_3 \rightleftharpoons Na_2Z + CaCO_3$$

the quantities of soda carbonate adsorbed and calcium exchanged were not equivalent. The soda carbonate was always greater than the exchangeable Ca^{++} replaced by Na^+. Different equations, e.g. Langmuir's and Vageler's, have been examined for their applicability to this reaction, but none of them has been found to apply satisfactorily. A new equation has been proposed which follows the exchange reaction more closely, viz.:

$$X = \frac{\mu + BI}{\lambda + I}$$

where X = Ca exchanged, B = base exchange capacity, I = initial concentration of sod. carbonate, and μ, λ are constants.

95. Freundlich's adsorption isotherm applied to soils.

M. R. NAYAR *and* K. P. SHUKLA, Lucknow.

In the experiments previously reported in connection with the sodium carbonate treatment of canal beds for preventing seepage losses it was found that a particular sample of soil to attain its maximum impermeability required the addition of 6% Na_2CO_3. This works approximately to 12 to 15 times the equivalent of exchangeable Ca normally present in the soils. The necessity for the addition of such a large quantity of the reagent required some explanation. To clear some of these points certain adsorption experiments were performed which led to the following conclusions: (*a*) The adsorption of Na_2CO_3 by pure Ca-soils was governed by the Freundlich equation:

$$Y = ac^{1/n}$$

where Y = sodium carbonate adsorbed; c = equilibrium concentration of sodium carbonate and '*a*' and '*n*' constants.

The constant '*a*' is related to the base exchange capacity B of the soil, and the modified equation takes the form

$$Y = 31 \times 10^{-5} \times B^2 c^{1/n}$$

The variation of '*n*' is within very narrow limits (0·8 to 1·1) for nine soils studied.

96. Studies on base-exchange and electro-kinetic properties of synthetic and naturally occurring alumino-silicates.

S. P. Raychaudhuri *and* A. K. M. Qudrati-Ghani, Dacca.

Synthetic alumino-silicates of widely varying silica-alumina ratios have been prepared by mixing colloidal solutions of silica and alumina and their base-exchange properties, buffer curves and electro-kinetic behaviour have been studied. The quantities of free silica and free alumina present in the precipitates have been determined and the properties of the residues after removing the free silica and free alumina from the precipitates have also been studied. These properties of the synthetic alumino silicates have been compared with similar properties of some naturally occurring alumino-silicates like kaolin, montmorillonite, beidellite, and halloysite.

97. Study of the molecular structure of some selenites.

S. S. Dharmatti *and* C. R. Kanekar, Bombay.

Prasad and Dharmatti (*Proc. Ind. Acad. Sci.*, 1940, **12**, 185) have measured the susceptibility of selenious acid and silver selenite and have come to the conclusion that both of them have an unsymmetrical structure. Other selenites have also been investigated by the authors and the results obtained have confirmed the unsymmetrical structure of these salts. The study of barium selenite presents a special interest as in this case the difference in the values calculated for the symmetrical and unsymmetrical structures is very small. This shows that the magnetic method can be used for finding out the molecular constitution of a substance only when there is a wide difference in the calculated values for the possible structures of the substance.

98. Ionic susceptibility of barium from salts of organic acids.

Mata Prasad, S. S. Dharmatti, *and* C. R. Kanekar, Bombay.

The susceptibilities of some barium salts of inorganic acids were measured by a modified form of Guoy's balance and the results obtained showed that the mean ionic susceptibility of barium ($-32{\cdot}21 \times 10^{-6}$) obtained from these salts is in good agreement with the values calculated by Slater's ($-33{\cdot}3 \times 10^{-6}$) and Angus's ($-31{\cdot}51 \times 10^{-6}$) methods, respectively. Barium salts of organic acids have now been investigated and the mean ionic susceptibility of barium obtained therefrom ($-42{\cdot}62 \times 10^{-6}$) is considerably higher than the theoretically calculated values. This observation is in confirmity with that of Trew (*Trans. Faraday Soc.*, 1936,

32, 1658) on thallium salts of organic acids. The observed increase in the ionic susceptibility seems to be due to the increase in the ionic radius as a result of the increase in the size of the negative ion surrounding the barium ion. Calcium and strontium salts are being investigated on similar lines to test this point of view.

99. Dia-magnetic susceptibility of benzil.

(MISS) R. S. REPORTER *and* M. QURESHI, Hyderabad-Deccan.

Dia-magnetic susceptibilities of alcoholic solutions of benzil have been determined over a wide range of concentration, employing Guoy's method. The susceptibility-concentration graph is a straight line which cuts the susceptibility axis at a point corresponding to the susceptibility of alcohol, the maximum deviation from linearity being not more than 1%. The value obtained for the gram-susceptibility of benzil by extrapolation is $-\cdot531\times10^{-6}$ which corresponds to a value of $-111\cdot45\times10^{-6}$ for the molecular susceptibility of benzil. This value is in close agreement with that calculated on the basis of the diketone formula. The constitution of benzil has been discussed.

100. Dia-magnetic susceptibility of paraldehyde.

(MISS) R. S. REPORTER *and* M. QURESHI, Hyderabad-Deccan.

Dia-magnetic susceptibility of pure paraldehyde has been determined, employing Gouy's method. As an average of several readings, the gram-susceptibility comes out to be $-\cdot6387\times10^{-6}$ which corresponds to a value of $-84\cdot316\times10^{-6}$ for the molecular susceptibility of paraldehyde. This value is in very close agreement with that calculated on the basis of a cyclic triacetal structure and differs considerably from that calculated on the basis of a straight chain structure. The constitution of paraldehyde has been discussed.

101. Dia-magnetic susceptibility of metaldehydes.

(MISS) R. S. REPORTER *and* M. QURESHI, Hyderabad-Deccan.

Dia-magnetic susceptibility of metaldehyde in the solid state has been determined employing Gouy's method. As an average of three determinations the value of gram-susceptibility comes out to be $-\cdot463\times10^{-6}$. It is less than that obtained by Pascal for acetaldehyde which is $-\cdot502\times10^{-6}$. This indicates that polymerization in this instance has resulted in an increase in the number of double bonds rather than a decrease as in the case of paraldehyde. The problem needs further investigation before any definite conclusion can be reached with regard to the structure of metaldehyde.

102. Dia-magnetic susceptibilities of optical isomers of tartaric acid.

N. CHARY *and* M. QURESHI, Hyderabad-Deccan.

Dia-magnetic susceptibilities of aqueous solutions of *d*-tartaric acid, meso-tartaric acid, and racemic acid have been determined over a wide range of concentration and the dia-magnetic susceptibilities of pure compounds have been extrapolated from the susceptibility concentration curves.

No definite variation in the dia-magnetic susceptibilities of the stereoisomers, namely, *d*-tartaric acid, mesotartaric acid and racemic acid has been noted.

The susceptibility-concentration graph for racemic acid shows a break at 11% concentration. This indicates that at higher concentrations racemic acid exists as a molecule, composed of two ordinary tartaric acid molecules, which are joined together by single bonds through oxygen atoms of the 'COOH' groups. At lower concentrations this complex molecule breaks up into simple tartaric acid molecules. This is supported by the results obtained by Stuart from the measurements of interfacial tensions of *d*-tartaric acid, *l*-tartaric acid and racemic acid and some inert liquids such as toluene and paraffin.

103. Dia-magnetic susceptibility of meta-tartaric acid.

N. Chary *and* M. Qureshi, Hyderabad-Deccan.

Meta-tartaric acid has been prepared in a pure condition and the dia-magnetic susceptibility of its aqueous solution over a wide range of concentration. The magnetic susceptibility of meta-tartaric acid extrapolated from the curve is found to be about 20% greater than that of ordinary tartaric acids. These results indicate that meta-tartaric acid is a polymer and not an isomer of tartaric acid as is generally assumed. The value of n in $(C_4H_6O_6)$ is found to be '7'. A structural formula for this polymer meta-tartaric acid has been suggested.

104. Passivity of magnesium and aluminium.

G. Ramarao, Hyderabad-Deccan.

Magnesium and aluminium exhibit passivity when exposed to ultra-violet radiations under atmospheric conditions. The degree of passivity is measured by the displacement of copper from a solution of copper sulphate. A slow current of dry air does not affect the metals but a rapid current slightly activates. A stream of dry air bubbled vigorously through concentrated sulphuric acid and passed over phosphorus pentoxide passivates them while a current of pure dry hydrogen under the same conditions strongly activates the metals. An attempt is made to explain these phenomena in the light of the existing theories of passivity.

105. Studies in salting-out effect. Part I.

M. D. Avasare *and* J. S. Dave, Baroda.

In this part of the investigation, effects of the addition of alkali halides on the solubilities in water of the halogen substituted benzoic acids have been studied.

It has been observed that (i) the salting-out effect increases with increase in concentration of the added electrolyte, (ii) the bromides appear to be more effective as salting-out agents than the chlorides and the iodides, and (iii) the effect is greater in the case of meta substituted halogen acids than with the ortho substituted ones.

106. Studies in solutions of aluminium hydroxide in alkali hydroxides.

S. M. Mehta *and* V. T. Sheth, Bombay.

Equilibrium concentrations of solutions obtained by shaking aluminium hydroxide with solutions of the hydroxides of sodium and potassium were studied. For this purpose, four different samples of aluminium hydroxides were used: (i) obtained by precipitation from aluminium sulphate, (ii) Merck's sample as obtained from the manufacturers, (iii) obtained by precipitation from aluminium chloride, and (iv) obtained by the hydrolysis of aluminium ethoxide.

The concentration of the alkali was varied between $1N$ and $14N$ and various mixtures were kept at different temperatures between 35° and 55°C. The results show that the solubility follows the order given above for the different samples, being greatest for the sample obtained from aluminium sulphate and least for that obtained from aluminium ethoxide. It is also found that the solubility of each sample increases with the concentration of the alkali as well as with increase in temperature. The amount of alumina precipitated by the addition of an electrolyte has been determined in each case and it is noticed that the amount of alumina thus precipitated is in the reverse order of solubility, i.e. largest amount is precipitated from the sample obtained from aluminium ethoxide whereas the least amount is obtained from the sample obtained from aluminium sulphate.

107. Studies on the iodination of different unsaturated organic compounds in the dark as well as in light of different frequencies in various non-polar and polar solvents.

S. K. BHATTACHARYYA, Bangalore.

Investigations have been carried out on the thermal iodination of β-amylene and α-pinene in non-polar solvents like benzene, carbon tetrachloride and carbon disulphide and iodination of β-amylene and phenyl acetylene in polar solvents like acetic acid and absolute alcohol. The reactions have been found to be reversible and the equilibrium constants have been determined under different experimental conditions. In non-polar solvents, the reaction is termolecular with respect to iodine but unimolecular with respect to the acceptor, i.e. it is quadrimolecular with respect to both; whereas in polar solvents, the reaction is termolecular with respect to both. Investigations have also been carried out on the photo-chemical iodination of phenyl acetylene, dicyclopentadiene, β-amylene, dimethyl acetylene dicarboxylate and phenyl propiolic acid in 546, 436 and 366 $\mu\mu$ in non-polar solvent like carbon tetrachloride and in polar solvent like absolute alcohol. The reaction is unimolecular with respect to iodine in both the solvents. The reaction is reversible and does not proceed to completion. A comparative study has been made on the kinetics and mechanism of the thermal as well as the light reactions.

108. Studies on the photo-bromination of cinnamic acid in wavelength 254 $\mu\mu$.

S. K. BHATTACHARYYA, Bangalore.

The kinetics and mechanism of the bromination of cinnamic acid in wavelength 254 $\mu\mu$ in solution of carbon tetrachloride have been studied. Results indicate that the kinetics and mechanism of the reaction are quite different from those found with visible light by various workers. The reaction has no induction period and is unimolecular with respect to bromine as well as with respect to cinnamic acid. The most peculiar feature of the reaction is that the velocity of the reaction is directly proportional to the intensity of radiation absorbed by cinnamic acid. The quantum efficiency is high. The velocity of reaction is independent of the nature of light exposed.

109. Influence of concentration on the physical properties of acidoid gum arabic.

S. N. MUKHERJEE, Calcutta.

A study on the influence of concentration on different properties has been helpful in showing that at higher sol concentrations there is some evidence of the formation of aggregates. Although a second factor, viz.

the hydration of particles influence these properties to a certain extent there are some unmistakable indications of the micellar association from some of these properties. The previous work at lower concentrations has indicated the existence of aggregates at all concentrations, however low that might be. If this fact be correlated with the observations made in the present investigation the conclusion seems to be justified that in the solution of the acidoid gum arabic the process of aggregation goes on at all concentrations and the assumption of a critical concentration appears to be unnecessary. This is, however, perfectly in conformity with the assumption that the aggregation proceeds by cohesive or Van der Waals' forces which cannot be assumed to be saturated in the same sense as the primary or chemical forces.

110. Influence of temperature on specific conductivity of acidoid gum arabic.

S. N. MUKHERJEE, Calcutta.

In understanding the influence of temperature on specific conductivity the rôle of hydration and aggregate formation in such cases should also be taken into consideration. The characteristic way in which specific conductivity changes with temperature presents some difficulties if explained from the view-point of the change of dielectric constant and mobility alone. The existence of the pseudo-form of the acid advocated by Pauli and co-workers appears to be doubtful in view of the behaviour of the salts of the acid so far as the equivalent conductivity is concerned, and further independent proofs appear to be essential before this can be accepted finally.

111. Electrochemical properties of concentrated acidoid gum arabic sol.

S. N. MUKHERJEE, Calcutta.

The effect of different bases and salts on the electro-chemical properties of the sol reveal that different bases give different total acidities of the same sol, a difference which is maintained even in the case of the ultrafiltrate. This difference though small is, however, significant both in conductometric and potentiometric titrations. In the interaction of the sol with the chlorides of $Na^{\cdot}$ and $Ba^{\cdot\cdot}$ both hydrogen ion activity and chlorine ion activity of the sol undergo change in presence of the sol. With barium ion the change is more marked than with sodium. Similar observations are made in the ultrafiltrate as well. Both hydrogen and chlorine ion activities behave similarly excepting at very low salt concentrations when only the relationship between sodium and barium becomes reversed. With hydrochloric acid as well some peculiar features have been noticed both in the sol and its ultrafiltrate.

Organic Chemistry

112. On synthesis of santalol and related compounds.

P. C. GUHA *and* S. C. BHATTACHARJI, Bangalore.

In continuation of the work reported last year (*Proc. Indian Sci. Cong.*, 1941, p. 74), and with the ultimate object of synthesizing the sesquiterpene alcohol, santalol, the synthesis of some of its simpler degradation products, viz. teresantalic acid, teresantalol, etc., has been extended. As the method of preparation of 8-chloro-camphor, by the method described last year, gives very poor yield, the preparation of the chloro-compound has been tried starting from α-chloro-camphor via α : 8-dichloro-camphor.

8-Bromo-camphor has been conveniently made in good yield. Work on the conversion of 8-bromo-camphor into 8-hydroxy-camphor, as also the direct linking of the 2 : 6-carbon atoms of 8-hydroxy-camphor *via* its hydrazone is described.

113. On sulphanilamide derivatives possessing heterocyclic rings. Part II. Action of *p*-acetamino-benzene sulphonyl chloride with heterocyclic amines.

P. C. GUHA *and* DEBABRATA DAS-GUPTA, Bangalore.

In continuation of the work reported last year (*Proc. Indian Sci. Cong.*, 1941, p. 89) acetylaminobenzene sulphonyl chloride does not react with phenyldithiobiazolonaminophenylsulphide; phenyldithiobiazolonaminotolylsulphide, and phenyldithiobiazolonhydrosulphamin. Acetylaminobenzenesulphonyl chloride reacts with (1) iminodihydrothiobiazolemethylthiol, (2) diaminotetrahydrothiobiazole, (3) 2-amino-thio($\beta\beta_1$)-biazole, and (4) 5-methyl-2-aminothio-($\beta\beta_1$)-biazole to give the corresponding acetylamino sulphonyl compounds of (1), (2) (m.p. 252–54°), (3) and (4) (m.p. 210–212°), respectively. The acetylamino compounds have been hydrolyzed to the free amino compounds. Their toxicity and therapeutic efficiency are under investigation.

114. Synthesis of sulphanilamide compounds possessing selenoheterocyclic rings.

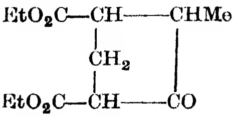
P. C. GUHA *and* A. N. ROY, Bangalore.

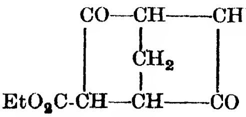
In continuation of the work reported last year (*Proc. Indian Sci. Cong.*, 1941, p. 89) 2-amino-4-methyl-selenazole, 2-amino-4-phenylselenazole, 2-amino-4-methyl-5-carboxy-selenazole and seleno-hydantoin, prepared with some modifications on the older methods, have been made to react with *p*-acetaminobenzene sulphochloride to give 2-(*p*-acetaminobenzene-sulphonyl) amino-4-methyl selenazole (I), 2-(*p*-acetamino-benzenesulphonyl)-amino-4-phenyl selenazole (II), 2-(*p*-acetamino-benzene-sulphonyl)-amino-4-methyl-selenazole-5-carboxylic acid (III) and 2-(*p*-acetylamino-benzene sulphonyl)-amino-seleno-hydantoin (IV), respectively. The acetyl compounds I, II and III, on hydrolysis, have yielded the corresponding amino-compounds, viz.: 2-(*p*-amino-benzenesulphonyl)-amino-4-methyl selenazole (V), 2-(*p*-amino-benzenesulphonyl)-amino-4-phenyl-selenazole (VI), and 2-(*p*-amino-benzenesulphonyl)-amino-4-methyl-selenazole-5-carboxylic acid (VII). The therapeutic efficiency and toxicity of these compounds will be studied soon.

115. On a new method of synthesis of the norbornylane system.

P. C. GUHA *and* V. R. SRINIVASAN, Bangalore.

The keto-dicarboxylic acid reported last year (vide *Proc. Indian Sci. Cong.*, 1941, p. 75) has been esterified, and the pure ester (I) has the b.p. 170–75°/2-3 mm. This ester has been cyclized to give the diketomonocarboxylic ester (II) which is a solid melting at 90°. This, upon hydrolysis and Clemmensen reduction, is expected to yield the norbornylane derivative (III).


(I)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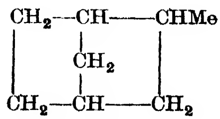

(III)

116. Synthesis of sulphanilamide derivatives possessing heterocyclic rings.

P. C. GUHA *and* V. M. DOKRAS, Bangalore.

The paper describes the action of *p*-acetylaminobenzenesulphonyl chloride and other allied sulphochlorides upon 2 : 6-diaminothianthren and aminobenzodithiins, etc., with a view to study the antibacterial action of the synthetic sulphonamides.

117. Preparation of barbiturates.

P. C. GUHA *and* M. S. MUTHANNA, Bangalore.

Experimental conditions for the laboratory preparation of barbiturates, such as veronal, pheno-barbitone (Luminal), adalin, dial, amytal, etc., have been established. Chloracetic acid required for the preparation of ethyl malonate (one of the starting materials for the preparation of barbiturates) was prepared from acetic acid from Bhadravati lime acetate and conditions for the preparation of ethyl malonate have been worked out thoroughly.

118. Extension of Reformatsky reaction. Part II. Condensation of ethyl bromomalonate with methyl ethyl ketone and *cyclo*hexanone.

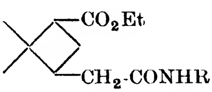
B. H. IYER, Bangalore.

It has been shown (*J. Indian Chem. Soc.*, 1940, **17**, 215) that the condensation of ethyl bromomalonate with acetone followed an unexpected course, yielding acetonyl *iso*propyl malonate which was cyclized and hydrolyzed successively to methone. The same bromo-ester has now been condensed with methyl ethyl ketone and *cyclo*hexanone and the products of reaction are being characterized.

119. Synthetical experiments in the pinane group. Part VII. Further attempts to synthesize pinonic acid.

P. L. NARASIMHA RAO, Bangalore.

In continuation of the experiments on the synthesis of pinonic acid described in Part VI of this series (*J. Indian Inst. Sci.*, 1939, **22*A***, 317), the study of the preferential hydrolysis of the ester group in compounds (I) by various reagents has been pursued. It is found that conc. sulphuric acid smoothly hydrolyzes the diphenyl derivative (I, R = Ph_2) to the free acid (II), m.p. 139°, with the nitrogenous residue remaining intact. This hydrolysis can also be effected to varying extent by means of castor seed lipase, or 10% alcoholic potash.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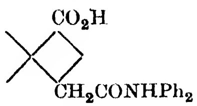

(II)

A Blaise's reaction using zinc-methyl iodide on the acid chloride of (II) has resulted mainly in the esterification of (II); however, by testing the product with Girard's reagent, it was noted that some traces of ketonic bodies were formed. Further experiments are in progress.

120. Iodination of unsaturated compounds.

M. JAGANNADHA RAO, Bangalore.

In continuation of the work already done on the iodination of β-amylene and pinene in the dark (*J. Indian Chem. Soc.*, 1941, **18**, 245) the reactions of iodine with other unsaturated compounds like camphene and α-amylene are being studied in different solvents under varying conditions of concentration and temperature. Considerable variation in the behaviour of iodine towards these compounds is noticed.

121. Re-examination of the alkaloids of the fruits of *Solanum xanthocarpum*.

B. L. MANJUNATH *and* M. SHADAKSHARASWAMY, Bangalore.

Owing to the discrepancies noticed between the work of Syed and Kanga (*Proc. Ind. Acad. Sci.*, 1936, 4A, 255) and that of Gupta and Dutt (*J. Indian Chem. Soc.*, 1938, **15**, 95) the alkaloidal constituents of an authentic specimen of the seeds of *Solanum xanthocarpum*, were re-investigated. The gluco-alkaloid, solancarpine, $C_{44}H_{77}O_{19}N$, was found to melt at 260°C. On hydrolysis it gave solancarpidine, $C_{26}H_{43}O_3N$ (m.p. 197-98°), glucose, rhamnose and galactose. The formulae of the alkaloids have been established by repeated and careful analyses. The paper also contains the study of some of the simpler derivatives of solancarpidine.

122. Chemical investigation of the fatty oil from the seeds of *Xylia xylocarpa*.

B. L. MANJUNATH *and* B. S. NAGARAJ, Bangalore.

Xylia xylocarpa is a big tree indigenous to Central and South India. Its seeds are edible and contain 14% of an oil which has the following constants:—sp. gr. (25°/25°), 0·9145; $n_{25°}$, 1·4700; sap. val., 181; acid val., 11; acetyl value, 11; iodine val., 90; Reichert Meisel val., 0·26; unsaponifiable matter 1·6%; saturated acids, 21·6%; mean mol. wt. of total acids, 321; —of saturated acids, 353; —of liquid acids, 312. The paper deals with the identification of the various constituents of the oil.

123. On the alkaloidal constituents of *Alstonia scholaris*.

S. SIDDAPPA, Bangalore.

The bark of *Alstonia scholaris* obtained from the forests in Shimoga area gave 0·5 p.c. of echitamine hydrochloride. A large quantity of the alkaloid has been prepared by a modified method and its constitution is now under investigation. Attempts to prepare in a pure state the other alkaloids, said to be present in the *A.* species have so far been unsuccessful.

Owing to the reputed antimalarial properties of the bark, its tincture is under clinical investigation. A sample of the hydrochloride has been sent for pharmacological study.

124. Synthesis of 6-keto-Δ^4-decenoic acid.

P. C. MITTER *and* DAMBARUDHAR GOGOI, Calcutta.

In connection with some synthetic work we were in need of 6-keto-Δ^4-decenoic acid which was synthesized in the following way:—Formyl succinic ester, prepared by condensing formic ester with succinic ester in presence of sodium, gave on careful hydrolysis β-aldehydo-propionic ester. On condensing the aldehydo ester with malonic acid in pyridine solution and working in the usual way, adipenic ester acid $COOEt.CH_2CH_2CH = CH.COOH$, b.p. 150°–160°/6 mm. was obtained.

The ester acid was converted into the ester chloride b.p. 130°–135° 14 mm. by treating with PCl_5 in benzol. This was condensed with propyl acetoacetic ester in ethereal solution and the product hydrolyzed by shaking with alcoholic potash at the ordinary temperature for 40 hours when 6-keto-Δ^4-decenoic acid was obtained. The acid melts at 178°–180° with previous softening at 175°.

125. Studies in the Fries migration. Part I.

R. D. DESAI *and* C. K. MAVANI, Bombay.

As the Fries migration of orcinol diacetate gave a good yield of the mixture of γ-orsacetophenone-(2 : 6-dihydroxy-4-methyl-acetophenone) and 2 : 4-diacetyl-5-methyl resorcinol, we have heated various orcinol esters in presence of anhydrous aluminium chloride, and find that there is a tendency for the acyl groups to take up the γ-position to a considerable extent. This reaction, thus, furnishes us with a new method of preparing some γ-derivatives of orcinol. The reaction has been extended to various dihydric and trihydric phenol derivatives.

126. Some reactions of aryl *p*-toluenesulphonic esters.

R. D. DESAI *and* C. K. MAVANI, Bombay.

Mono- as well as di-*p*-toluenesulphonates of resorcinol and hydroquinone were heated with aluminium chloride in order to see whether the migration of *p*-toluenesulphonyl group from oxygen to carbon would take place or not. The results were negative. Similar negative results were obtained in the condensation of *p*-toluenesulphonyl chloride with aromatic hydrocarbons in presence of anhydrous aluminium chloride. Unsuccessful attempts were also made to bring off the Baker-Venkataraman transformation of 2-acetyl-1-*p*-toluene-sulphonyl-α-naphthol by the method of Shah, Ullal and Wheeler. It seems that in spite of strong superficial resemblance, the chemical properties of the acetyl and *p*-toluenesulphonyl groups vary enormously.

127. Studies in naphthalene series. Part XII. Preparation of 1-lauryl, 1-palmityl- and 1-stearyl-2-naphthols.

R. D. DESAI *and* W. S. WARAVDEKAR, Bombay.

The Nencki reaction with β-naphthol and lower members of the aliphatic acids does not go well. However, when lauric, palmitic and stearic acids were used, the reaction went smoothly and good yields of 1-lauryl-, 1-palmityl-, and 1-stearyl-2-naphthols were obtained. These new ketones were then subjected to various reactions such as bromination, nitration, reduction and Kostanecki acylation.

128. Studies in naphthalene series. Part XIII. Further experiments on the synthesis of 4-lauryl-, 4-palmityl- and 4-stearyl-1-naphthols.

R. D. DESAI *and* W. S. WARAVDEKAR, Bombay.

In continuation of our work on 4-acyl-1-naphthols, we have already reported the synthesis of 4-lauryl-, 4-palmityl- and 4-stearyl-1-naphthols. (*Proc. Ind. Acad. Sci.*, 1941, **13**, 39). However, as the yields obtained by these methods were not satisfactory, we examined two alternative methods. The first method consisted in condensing 2-acetyl-1-naphthol with lauryl chloride, when an excellent yield of 2-acetyl-4-lauryl-1-naphthol was obtained. The Kostanecki acetylation of this diacyl-1-naphthol gave the chromone, the alkaline hydrolysis of which furnished the original diacyl ketone, and not the carboxylic acid. This method was, therefore, ruled out of practical consideration. The second method consisted in condensing lauryl chloride with 2-carbomethoxy-1-naphthol, when a mixture of 2-lauryl-1-naphthol and 2-carbomethoxy-4-lauryl-1-naphthol was obtained, and the decarboxylation of the corresponding acid gave 4-lauryl-1-naphthol. Investigations along similar lines were carried out using palmityl and stearyl chlorides.

129. Heterocyclic compounds. Part XVII. Coumarins from 2-ethyl-orcinol and β-ketonic esters.

R. D. Desai *and* C. K. Mavani, Bombay.

7-Hydroxy-coumarins from orcinol are rare and some of them have recently been prepared by Sethna and Shah (*J. Indian Chem. Soc.*, 1940, **17**, 211, 239). Our attempts to condense 2-acylorcinols with β-ketonic esters in order to obtain 7-hydroxy-coumarin derivatives have failed, as only 5-hydroxy-coumarins are formed owing to deacylation. γ-Orcacetophenone, which can now be easily prepared by the Fries migration of orcinol diacetate, was reduced to 2-ethylorcinol and when this rare dihydric-phenol was subjected to the Pechmann reaction, 7-hydroxycoumarins were obtained in good yield. Coumarins have been prepared from acetoacetic, alkyl-aceto-acetic, and benzoylacetic esters.

130. Heterocyclic compounds. Part XVIII. α- and β-naphtha-chromones and naphtha-coumarones containing long-chain alkyl radicals.

R. D. Desai *and* W. S. Waravdekar, Bombay.

2-Lauryl-, 2-palmityl- and 2-stearyl-1-naphthols and 1-lauryl-, 1-palmityl- and 1-stearyl-2-naphthols have been subjected to the Kostanecki reaction to obtain the chromones having long-chain alkyl radicals in the 3 position and the properties of these compounds are studied. The same hydroxy-ketones have been condensed with bromacetic ester, and the resulting carboethoxy methyl ethers give readily the required α- and β-naphtha-coumarones on treatment with sodium ethoxide.

131. Sulphanilamide derivatives.

R. D. Desai, J. B. Irani, *and* C. V. Mehta, Bombay.

New sulphanilamide derivatives have been obtained by condensing *p*-acetamino-benzenesulphonyl chloride with 1-aminobenzthiazole and its substitution derivatives. *p*-Dibenzylaminosulphonyl-chloride has been obtained by the sulphonation of dibenzylaniline and converted into the amide and the anilide, both of which are expected to be therapeutically useful, as *p*-benzylaminosulphanilamide is already used in medicine. Finally, azobenzene has been sulphonated to give azobenzene-4 : 4′ disulphonyl chloride and the amide and substituted amides have been obtained. These substances are particularly interesting, as they should liberate two molecules of sulphanilamide or its derivatives *in vivo*. We hope to be able to get the pharmacological tests carried out in the near future.

132. *o*-Hydroxy-aryl-ketones as ingrain dyes.

R. D. Desai, P. N. Joshi, *and* S. Muthukrishnan, Bombay.

As the only recorded instance of an *o*-hydroxy-aryl-ketone suggested for ingrain dyeing is CIBA Naphthol R.P. or 4-benzoyl-1-naphthol (D.R.P. 211, 223) we have investigated the possibilities of using other hydroxy-aryl-ketones in this respect. 4-Acetyl-1-naphthol, an elegant method for the preparation of which has been described by Akram and Desai (*Proc. Acad. Sci.*, 1940, **11**, 149), has been found to be a very interesting ketone in this respect; and we have carried out an extensive series of dyeing trials using the various azo salts. The homologues of 4-acetyl-1-naphthol are also equally useful. By an application of the Friedel-Craft's reaction to 2-hydroxy-3-naphthoyl chloride we have synthesized 2-hydroxy-3-benzoyl-, 2-hydroxy-3-*p*-toluyl- and 2-hydroxy-3-α-naphthoyl-naphthalene. These ketones resemble naphthol A in respect of their alkaline solutions, being substantive to cotton. A number of diazo salts have been used for coupling and the shades produced are fast to light, soaping and 1% hypochlorite solution.

133. Use of *o*-hydroxy-aryl-ketones in printing.

R. D. DESAI, P. N. JOSHI, *and* S. MUTHUKRISHNAN, Bombay.

4-Acetyl-1-naphthol and 3-benzoyl-2-naphthol can be used in place of Naphthol A.S. for printing purposes. The cloth can be prepared by padding with an alkaline solution of these ketones, and the naphthols are developed by printing with a paste prepared from stabilized azo-salts and solution of British gum. The prints are bright and fast to washing and soaping.

134. The cyanine dyes of the pyridine series. Part II.

M. Q. DOJA *and* DHANUSHDHAR PARSAD, Patna.

p-Dimethylamino-benzaldehyde has been condensed respectively with α-picoline-methiodide, -ethiodide, -propyl iodide and -butyl iodide; and the chemical dyeing and photographic properties of the compound thus produced examined, with a view to investigate the influence of change of structure on the properties of these dyestuffs, specially their sensitizing power.

135. Syntheses of γ-keto fatty acids.

J. J. TRIVEDI *and* K. S. NARGUND, Ahmedabad.

Following the keto acid synthesis of Mrs. Robinson γ-ketodecylic acid m.p. 71° and γ-ketonondecylic acid m.p. 95-96° have been prepared and characterized by suitable derivatives. A new method has been developed for the preparation of γ-keto fatty acids which consists in treating the Grignard reagent of an appropriate alkyl bromide or iodide with succinic anhydride under suitable conditions. A number of γ-keto acids including the two described above have been prepared by the latter method.

136. Synthetical anthelmintics. Synthesis of γ-alkyl-γ-*p*-methoxyphenylbutyrolactones.

J. J. TRIVEDI *and* K. S. NARGUND, Ahmedabad.

The butyrolactones mentioned in the title of this paper have been prepared by (i) the action of a Grignard reagent of an alkyl bromide on ethyl β-*p*-methoxybenzoyl propionate, and (ii) by the action of the Grignard reagent prepared from *p*-bromoanisole on the ethyl esters of γ-keto fatty acids. In some cases the corresponding γ-hydroxy butyric acids obtained from neutralization of an alkali solution of a lactone in cold have been described. Lactones containing alkyl groups up to cetyl have been prepared.

137. Sulphonation of anthranilic acid.

B. L. BHAT *and* K. S. NARGUND, Ahmedabad.

Sulphonation of anthranilic acid under various conditions has been attempted. It has been found that sulphuric acid containing up to 5% sulphur trioxide when heated with anthranilic acid at 170–180° for 10–15 minutes gives 3 sulphoanthranilic acid the constitution of which has been proved by its conversion into 3-sulphosalicylic acid by diazotization. The action of bromine on the sulpho acid has been found to give 3 : 5 dibromoanthranilic acid and tribromoaniline.

138. An attempt at the direct synthesis of substituted cinnamic acids.

B. D. PATEL *and* K. V. BOKIL, Ahmedabad.

Recently a new compound was isolated from the condensation of acetonedicarboxylic acid with anisole which was proved to be $\beta\beta$-di-substituted glutaric acid by its synthesis first from the condensation of acetoacetic ester with anisole, and secondly by the addition of anisole to *p*-methoxy-β-methylcinnamic acid,—both under the influence of 80% sulphuric acid, (Vyas and Bokil, *Rasayanam*, 1939, 198). This definitely indicated the formation of the substituted cinnamic acid as the intermediate product in the first synthesis. With a view to getting such acids, acetoacetic ester was condensed with phenolic ethers under the influence of different concentrations of sulphuric acid at the ordinary temperature over different periods of time, and using different quantities of reacting substances.

Sulphuric acid with concentrations lower than 80% produced little or no condensation. 80% acid produced substituted butyric acids (A) and their esters in more or less quantity, along with a trace of another acid (B) which was formed in a little larger quantity with 85% acid, which also produced some sulphonic acids along with the acids (A) and their esters. The acids (B) appeared to be addition products of a molecule of acetoacetic ester with the intermediate cinnamic acids. 90% acid, and other higher concentrations, produced mainly sulphonic acids. In no case could even a trace of the expected cinnamic acids, or their esters, be isolated under any conditions, presumably due to the rapid addition of the phenol ethers or, when this is more or less prevented, the acetoacetic ester to the intermediate cinnamic acids. These findings are in marked contrast to the claim made by Limaye (*Rasayanam*, 1939, 186) of having obtained small quantities of cinnamic acids from the condensation of acetoacetic ester with anisole and phenetole for which no details are given.

The addition of acetoacetic ester to the intermediate *p*-substituted cinnamic acids in the above condensations is interesting, since this addition reaction by the Michael method is known to be entirely prevented. Benzoyl acetic ester did not condense with phenol ethers under the above conditions. The ease with which phenol ethers can add to different β-substituted cinnamic acids is also being studied.

139. Syntheses of antileprosy drugs. Part I. A new synthesis of *w-cyclo*hexylundecylic acid—an analogue of dihydro-hydnocarpic acid.

(MISS) B. C. PANDYA, K. S. NARGUND, *and* K. V. BOKIL, Ahmedabad.

Hiers and Adams (*Jour. Amer. Chem. Soc.*, 1926, **48**, 1092) synthesized the *cyclo*hexyl analogue of dihydrohydnocarpic acid on the lines of their synthesis of dihydrohydnocarpic acid. The latter was recently synthesized by a new, and a simpler method by Bokil and Nargund (*Bomb. Univ. Jour.*, 1937, **6**, (II) 93). The *cyclo*hexyl analogue is now synthesized in a similar way.

Ethyl cyclohexanone-2-carboxylate was condensed in the form of its potassium salt with ethyl *w*-bromonundecylate giving the keto-diester (I) (b.p. 260°–270°/13 mm.). On hydrolysis with concentrated hydrochloric acid (I) gave a keto acid ester (II, b.p. 255°–265°/3 mm.); when boiled with 10% methyl alcoholic caustic potash (I) gave a mixture of keto acid ester (II) and a dibasic acid (III) which on distillation gives *cyclo*hexanone-2-*w*-undecylic acid (IV) as the first fraction (b.p. 260°–265°/13 mm.; m.p. 60°–62°; and semicarbazone m.p. 134°-135°). This was reduced by Clemensen's method to the required *w-cyclo*hexylundecylic acid (m.p. 57°-58°). Its ester and amide are also prepared.

140. Preparation of substituted cinnamic acids by the ring-opening of the coumarins.

K. G. Naik, R. K. Trivedi, *and* M. P. Shah, Baroda.

In the present study, conditions for the preparation of substituted *o*-coumaric acids from 4-alkyl- or 4-phenylcoumarins were investigated. The classical methods employed in this direction did not give successful results. However, by employing dimethyl sulphate to lock up the -OH group formed when the coumarins were dissolved in alkali, the substituted methoxy cinnamic derivatives were obtained. The following coumarins were subjected to this treatment: (i) 7-hydroxy-4-methylcoumarin; (ii) 7-hydroxy-4-methyl-3-ethylcoumarin; (iii) 7-hydroxy-4-phenylcoumarin; (iv) 7-hydroxy-4-methyl-3-allylcoumarin; (4) 5-7-di-hydroxy-4-methylcoumarin.

The first three substances gave the following acid derivatives: (i) 2 : 4-dimethoxy-β-methyl cinnamic acid, (ii) 2 : 4-di-methoxy-β-methyl-, α-ethyl cinnamic acid; (iii) 2 : 4-dimethoxy-β-phenyl cinnamic acid.

141. Interaction of nitrosyl chloride with the substituted amides of acetoacetic acid.

K. G. Naik, R. K. Trivedi, *and* B. N. Mankad, Baroda.

In order to study the reactivity of the methylene group $-CH_2-$, in the case of the substituted amides of acetoacetic acid, the interaction of nitrosyl chloride with the following substances was investigated: (i) aceto-acetanilide, (ii) aceto-acet-*o*-tolylamide, (iii) aceto-acet-*p*-tolylamide (iv) aceto-acet-1.3.4-xylylamide, (5) aceto-aceto-α-naphthylamide, (vi) aceto-acet-β-naphthylamide.

All the above compounds reacted with nitrosyl chloride yielding their respective yellow *iso*-nitroso-derivatives (oximes) without giving the corresponding isomers.

142. Interaction of substituted amides of acetoacetic acid with bromine.

R. K. Trivedi *and* M. P. Shah, Baroda.

Conditions of interaction of bromine with the following substituted amides of acetoacetic acid were investigated: (i) acetoacetanilide, (ii) aceto-acet-*p*-toluidide, (iii) aceto-acet-1.3.4.-xylidide, (iv) aceto-acet-*o*-toluidide, (v) aceto-acet-α-naphthylide.

Out of these, the first three gave the corresponding mono-bromo-derivatives.

It was found that the reactivity of one of the hydrogen atoms of the methylene group $-CH_2-$ in the case of acetoacetic acid is greater than that of the other hydrogen atom. The methylene group $-CH_2-$ in acetoacetic acid is more reactive than that in the other similar substances such as malonic acid, cyan acetic acid.

143. Interaction of sulphuryl chloride with the substituted amides of acetoacetic acid.

R. K. TRIVEDI *and* B. N. MANKAD, Baroda.

Conditions of interaction of sulphuryl chloride with the amides of acetoacetic acid were investigated. The following amides gave the corresponding mono-chloro-derivatives: (i) aceto-acet-anilide, (ii) aceto-acet-1 : 3 : 4-xylylamide, (iii) aceto-acet-α-naphthylamide.

It appears that the keto-enol transformation, which may be taking place even at lower temperature in the case of acetoacetic acid derivatives may be responsible for the easy formation of mono substituted derivatives. It was also found that the reactivity of one of the hydrogen atoms of the methylene group $-CH_2-$ in the case of acetoacetic acid is greater than that of the other hydrogen atom.

144. Condensation of phenols and phenolic ethers with acetone dicarboxylic acid. Coumarins and anhydrides of β-aryl glutaconic acids.

V. M. DIXIT *and* A. M. KANKUDATI, Dharwar.

Resorcin and *m*-cresol were condensed with acetone dicarboxylic acid in the presence of (i) anhydrous aluminium chloride, and (ii) phosphorus oxychloride as condensing agents. From the condensation products in each case, an acid (A) and a non-acidic substance (B) were separated. There was no difference between the products obtained by the use of either aluminium chloride or phosphorus oxychloride as the condensing agent. In the case of resorcin, the acid (A) was identified with 7-hydroxy-coumarin-4-acetic acid. The non-acid (B), according to the experimental evidence available at present, may be the anhydride of the corresponding β-2 : 4-dihydroxyphenyl glutaconic acid. Similarly, in the case of *m*-cresol, the acid (A) was identified with 7-methyl-coumarin-4-acetic acid and the nonacid is considered to be the anhydride of β-2-hydroxy-4-methylphenyl glutaconic acid. The nonacidic compounds (B) could be converted into the respective coumarin-4-acetic acids by boiling with (i) alkalies, and (ii) sulphuric acid (75%). They give acetyl, benzoyl and methyl derivatives which are still under investigation.

In view of the possible formation of glutaconic anhydrides, it is suggested that the condensation of acetone dicarboxylic acid in the ortho position with respect to the -OH group of the phenol yields simultaneously the *cis* and *trans* forms of the corresponding glutaconic acid and that while the *cis* changes to the corresponding coumarin-4-acetic acid, the *trans* gives the anhydride. Other phenols and phenolic ethers have also been condensed with acetone dicarboxylic acid by the use of aluminium chloride and phosphorus oxychloride. The products obtained are under investigation. Other condensing agents like P_2O_5, dry HCl gas, and sodium ethoxide have been successfully employed in the condensation of some phenols with acetone dicarboxylic acid.

145. Synthesis of 6-acetyl-8-ethyl-umbelliferone.

SHRIDHAR DATTATRAYA LIMAYE, Poona.

The present work was undertaken as a part of the scheme for the 'syntheses in the coumarin-γ-pyrone group', (D. B. Limaye, *Rasayanam*, 1937, **1**, 113; 1939, **1**, 169).

2-Ethyl-resorcin (Limaye and Miss Ghate, *Rasayanam*, 1936, **1**, 39), gave on condensation with malic acid in the presence of concentrated sulphuric acid, 8-ethyl-umbelliferone, m.p. 189°, $C_{11}H_{10}O_3$, (I) [acetate, m.p. 105°, (II) methyl ether, m.p. 158°, (III), benzoate m.p. 115°]. Hydrolysis of (III) gave 2-hydroxy-3-ethyl-4-methoxy-cinnamic acid, m.p. 166° (decomp.), $C_{12}H_{14}O_4$. On hydrolysis followed by methylation, (III) gave the methyl ester of 2 : 4-dimethoxy-5-ethyl-cinnamic acid, a liquid, which on hydrolysis furnished the acid m.p. 80°, $C_{13}H_{16}O_4$.

On treatment anhydrous aluminium chloride, (II) gave a compound m.p. 166°, $C_{13}H_{12}O_4$, (IV) giving red colouration with ferric chloride [semicarbazone m.p. not below 285°; acetate m.p. 118°]. (IV) gave on heating with sodium acetate and acetic anhydride a coumarino-pyrone, m.p. 233°, $C_{17}H_{14}O_5$, (V) thus showing (IV) to be 6-acetyl-8-ethyl-umbelliferone. On hydrolysis (IV) yielded 2 : 4-dihydroxy-3-ethyl-5-acetyl-cinnamic acid, m.p. 203° (decomp.) which on treatment with concentrated sulphuric acid regenerated (IV). (V) is under further investigation.

146. Synthesis of 2-acetyl-4-butyl-resorcin by the extension of the Nidhone process for the syntheses of 2-acyl-resorcins.

SHRIPAD VASUDEO PARANJPE, Poona.

The Nidhone process for the syntheses of 2-acyl-resorcins (Limaye, *Ber.*, 1934, **67**, 12) has been extended to the synthesis of 2-acetyl-4-ethyl-resorcin (Limaye and Limaye, *Rasayanam*, 1941, **1**, 201). The process has now been extended to the synthesis of 2-acetyl-4-butyl-resorcin.

4-Butyl-resorcin (Johnson and Lane, *Jour. Amer. Chem. Soc.*, 1921, **43**, 357) was condensed with acetoacetic ester to yield 6-butyl-4-methyl-umbelliferone, (I) m.p. 160°C., $C_{13}H_{16}O_3$ [acetate (II), m.p. 110°C.; benzoate, m.p. 116°C.; methyl ether, m.p. 168°C.]. (II) on treatment with anhydrous aluminium chloride gave a compound, (III) m.p. 132°C., $C_{16}H_{18}O_4$ [acetate, m.p. 122°C.; benzoate, m.p. 147°C.; methyl ether, m.p. 70°C. and semicarbazone, m.p. 220°C.], which on reduction gave 8-ethyl-6-butyl-4-methyl-umbelliferone, (IV) m.p. 146°C., of S.D. Limaye [acetate, m.p. 112°C.; benzoate, m.p. 166°C.; methyl ether, m.p. 70°C.]. Hence (III) could be represented as 8-acetyl-6-butyl-4-methyl-umbelliferone. (III) on hydrolysis with caustic alkali, yielded 2-acetyl-4-butyl-resorcin, (V) m.p. 70°C., $C_{12}H_{16}O_3$ [diacetate, a liquid; dibenzoate, m.p. 90°C.]. (IV) on reduction furnished 2-ethyl-4-butyl-resorcin, (VI) m.p. 65°C.

In keeping with 2-acyl-resorcins (V) and (VI) condensed with aceto-acetic ester to yield (III) and (IV) respectively.

147. Synthesis of β-(4-butoxy-phenyl)-glutaconic acid.

VISHNU KESHAV BAVADEKAR, Poona.

In continuation of Limaye and Bhave's work on β-aryl-glutaconic acids (*J. Indian Chem. Soc.*, 1931, **8**, 137), butyl ether of phenol was condensed with acetone-dicarboxylic acid, when β-(4-butoxy-phenyl)-glutaconic acid (I), $C_{15}H_{18}O_5$, m.p. 160°–170° (decom.), was obtained. The hydroxy-anhydride (II) of (I), $C_{15}H_{16}O_4$, m.p. 140°, gives colouration with ferric chloride and is titratable with alkali, (II) gives an acid-ethyl ester $C_{17}H_{22}O_5$, m.p. 110°; an acid-methyl ester, $C_{16}H_{20}O_5$, m.p. 115° and a semianilide, $C_{21}H_{23}O_4N$, m.p. 163° (decom.). On boiling with HCl (I) loses CO_2 and forms a neutral oil, apparently containing *p*-butoxy-*iso*-propylenebenzene.

148. Influence of an acyl group in the 3 position on reactions of chromones. Action of aluminium chloride on 5-acetoxy- and 5-benzoyloxy-2-methyl-3-acetyl-chromones.

GOVIND RAMCHANDRA KELKAR, Poona.

That an acetyl group in the 3 position in chromones exerts an inhibitive influence on Fries migration has already been shown in the 7-hydroxy-chromone series (Kelkar and Limaye, *Rasayanam*, 1936, **1**, 60; 1939, **1**, 183). The observations have now been extended to the 5-hydroxy-chromone series.

5-Acetoxy-2-methyl-3-acetyl-chromone (Limaye and Kelkar, *Jour. Ind. Chem. Soc.*, 1935, **12**, 788) also did not undergo Fries migration with aluminium chloride, but simply suffered desterification. 5-Acetoxy-2-methyl-chromone, however, furnished a ketone (I), $C_{12}H_{10}O_4$, m.p. 175°, semicarbazone m.p. 255° (decomp.) acetate, m.p. 160°. On hydrolysis (I) yielded an acid (II) $C_9H_8O_5$, m.p. 135°, which yielded on decarboxylation resacetophenone. Hence (I) may be 5-hydroxy-6 (8)-acetyl-2-methyl-chromone and (II) 2 : 6-dihydroxy-5-acetyl-benzoic acid.

Similarly, 5-benzoyloxy-2-methyl-3-acetyl-chromone, m.p. 157°, $C_{19}H_{14}O_5$ did not undergo Fries migration but 5-benzoyloxy- 2-methyl-chromone, smoothly furnished 5-hydroxy-6 (8)-2-benzoyl-2-methyl-chromone, m.p. 170°, $C_{17}H_{12}O_4$, which on hydrolysis yielded an acid m.p. 188° and 4-benzoyl-resorcin.

149. Synthesis of 2-butyryl-4-ethyl-resorcin by the extension of the Nidhone process for the syntheses of 2-acyl-resorcins.

MADHUKAR VASUDEO KURLEKAR, Poona.

The Nidhone process for the syntheses of 2-acyl-resorcins (Limaye, *Ber.*, 1934, **67**, 12) has been extended to the synthesis of 2-acetyl-4-ethyl-resorcin (Limaye and Limaye, *Rasayanam*, 1941, **1**, 201). The process is now used for the synthesis of 2-butyryl-4-ethyl-resorcin.

6-Ethyl-4-methyl-umbelliferone on boiling with *n*-butyryl chloride gave its butyrate, (I) $C_{16}H_{18}O_4$, m.p. 125°C. (I) on treatment with anhydrous aluminium chloride gave 8-butyryl-6-ethyl-4-methyl-embelliferone, (II), $C_{16}H_{18}O_4$, m.p. 106°C. [Acetate, $C_{18}H_{20}O_5$, m.p. 105°C.; benzoate, $C_{23}H_{22}O_5$, m.p. 120-121°C.] On hydrolysis with sodium hydroxide (II) yielded 2-butyryl-4-ethyl-resorcin, (III), $C_{12}H_{16}O_3$, m.p. 69-70°C., acetone and carbon dioxide. (III) on condensation with aceto-acetic ester yielded (II) a behaviour in keeping with 2-acyl-resorcins.

150. Halogenation. Part XXXVI. Halogenation of 1 : 6-dimethyl naphthalene.

P. S. VARMA *and* R. N. KAPOOR, Benares.

1 : 6-Dimethyl naphthalene has been chlorinated, brominated and iodinated under different conditions. By the action of chlorine two new chloro-compounds, a mono-chloro-derivative, b.p. 177-178°/25 mm. and a dichloro-derivative, b.p. 202-203°/25 mm. have been isolated and its constitution tentatively assigned. The mono-chloro-compound is considered to be 4-chloro-1 : 6-dimethyl naphthalene, and the dichloro- 4 : 5 or 4 : 8 dichloro- 1 : 6-dimethyl naphthalene. By the action of bromine also, two mono-bromo-derivatives one b.p. 176-177°/20 mm. and another b.p. 187-188°/20 mm. and a dibromo-derivative 4 : 5 or 4 : 8

dibromo- 1 : 6 dimethyl-naphthalene, m.p. 147°, have been obtained. One of the mono-bromo-derivative is considered to be 1′-bromo-1 : 6 dimethyl naphthalene and the other 4-bromo- 1 : 6-dimethyl naphthalene. It has been possible to obtain an iodo-derivative also, the properties and constitution of which are under investigation.

151. Halogenation. Part XXXIV. Halogenation of fluoro-toluenes.

P. S. Varma, Benares.

o-, *m*- and *p*-Fluoro toluenes have been directly chlorinated, brominated and iodinated under different conditions as a result of which 2-fluoro-5-chloro-toluene, 2-fluoro-5-chloro-benzoic acid, 2 fluoro-6-chloro-toluene, 2 fluoro-6-chloro-benzoic acid, 2-fluoro-6-chlorotoluene, 2-fluoro-6-chloro benzoic acid, 2-fluoro-5-bromotoluene, 2-fluoro-5-bromo-benzoic acid, 2-fluoro-6-bromotoluene, 2-fluoro-5-iodotoluene, 2-fluoro-6-iodo-toluene, 2-fluoro-4-iodotoluene, 3-fluoro-6-bromo-toluene, 3-fluoro-6-bromo benzoic acid, 3-fluoro-4-bromo-toluene, 3-fluoro-4-iodo-toluene, 3-fluoro-6-iodo-toluene, 4-fluoro-3-bromo-toluene, 4-fluoro-3-bromo benzoic acid, 4-fluoro-3-iodo-toluene, 4-fluoro-2-iodotoluene, 4-fluoro-3-iodo benzoic acid, *o*-fluoro-benzyl iodide, *m*-fluoro-benzyl iodide, *p*-fluoro-benzyl iodide, *o*-fluoro-benzal chloro-bromide, *m*-fluorobenzal chloro-bromide, *o*-fluoro-benzo-dichloro bromide, *m*-fluoro-benzo-dichloro bromide have been obtained and some of these for the first time.

Some of the fluoro-chloro-, fluoro-bromo- and fluoro-iodo-toluenes have also been obtained from the corresponding amino-compounds by the Sandmeyer's reaction and their constitution thus definitely established.

152. A new chemical evidence regarding the position of double bond and keto group in artostenone.

M. C. Nath *and* M. K. Chakraborty, Dacca.

It has been shown by Butenandt *et al.* (*Ber.*, 1938, **71**B, 1483), that cholestenone, which is an α-β-unsaturated ketone form a saturated di-hydroxy cholestanone on treatment with hydrogen peroxide in presence of osmic acid. The same reaction has been successfully applied to artostenone, which has previously (Nath, *Z. physiol. Chem.*, 1937, **247**, 16; 1937, **249**, 71, 78), been suggested to be an α-β-unsaturated ketone. The compound formed is the dihydroxy artostenone (m.p. 141-42°). The compound gives an acetyl derivative (m.p. 90°) showing the presence of hydroxyl groups. Formation of an oxime, (m.p. 215-16°) by the usual method, indicates the presence of the keto group in the compound. Thus the reaction serves a clear evidence that artostenone is an α-β-unsaturated sterol-ketone analogous to cholestenone, though the unsaturation and keto group are located at some different positions.

153. Distillation of glycerides under reduced pressure. Part I. Tristearin.

Y. V. Duvedi, N. L. Phalnikar, *and* B. V. Bhide, Poona.

Pure tristearin has been distilled under reduced pressure. Practically the whole of tristearin distills over, leaving no residue. The distillate consists of (i) tristearin, (ii) stearone, and (iii) stearic acid, with traces of hydrocarbons. During distillation considerable amount of acrolin and small amounts of carbon dioxide were given out. Further work on other synthetic glycerides of saturated and unsaturated acids is being carried out.

154. Distillation of Indian vegetable oils under reduced pressure. Part II. Safflower oil.

J. D. LAGWANKAR, N. L. PHALNIKAR, *and* B. V. BHIDE, Poona.

In continuation of our work on distillation of Indian vegetable oils (*Proc. 28th Ind. Sci. Congress*, 1941, III, 96) we have distilled safflower oil under reduced pressure (30 mm.). The products of distillation are: (i) a thick residue, (ii) distillate. The distillate has separated into (*a*) a neutral portion mainly consisting of unsaturated hydrocarbons, (*b*) saturated solid acids, and (*c*) unsaturated and saturated liquid acids. The liquid acids have been separated into three portions: (i) a lower fraction consisting mainly of a lower saturated acid (C_8), accompanied by another unsaturated acid which gives on oxidation succinic acid and C_6 saturated acid; (ii) the middle fraction yields on oxidation azelaic acid and hexoic acids, therefore, consists of oleic acid. Besides oleic acid it contains lower saturated acids (C_{10} and C_{12}) accompanied by a small amount of arachidic acid; (iii) in the higher fraction an unsaturated acid (mol. wt. 512) is found which yields on oxidation a gummy acid (equi. wt. 127) and a volatile acid (equi. wt. 162). Attempts to isolate this gummy acid in pure condition are so far unsuccessful.

It is to be noted that linolic acid which forms a major part of the original oil is not found in the distillate. From these products a tentative scheme of heat polymerization of oils is advanced.

155. Synthesis of coumarins from *o*-hydroxy-aryl alkyl ketones. Part V.

D. CHAKRAVARTI, Calcutta.

In continuation of the previous work (Chakravarti *et al.*, *J. Indian Chem. Soc.*, 1938, **15**, 136; 1939, **16**, 389; 1940, **17**, 65) *o*-hydroxy phenyl benzyl ketones, e.g. 2-hydroxy-5-methyl-phenyl benzyl ketone, 2-hydroxy-5 chloro-phenyl benzyl ketone, 2-hydroxy-3-chloro-5-methyl phenyl benzyl ketone, 2-hydroxy-3-methyl-5-chloro benzyl ketone, have been condensed with ethyl bromo-acetate and ethyl α-bromo-propionate and the unsaturated esters, thus obtained, have been converted to 4-benzyl-coumarin derivatives by heating with hydriodic acid.

156. Synthesis of coumarins from *o*-hydroxy-aryl alkyl ketones. Part VI.

D. CHAKRAVARTI, Calcutta.

4-Phenyl coumarin derivatives have been obtained from various 2-hydroxy benzophenones by condensation with ethyl bromoacetate and ethyl α-bromo propionate and subsequent demethylation of the unsaturated esters with hydriodic acid.

157. Occurrence of luteolin in the flowers of *Chrysanthemum indicum*.

P. SURYAPRAKASA RAO, Waltair.

Luteolin is present in the form of its glucoside in the yellow variety of the flowers of *Chrysanthemum indicum*, whereas the red, scarlet red and the deep red variety contains the anthocyanin, chrysanthemin. Just as the simultaneous occurrence of quercetin and cyanidin is frequent, a similar correlation between the corresponding flavone, luteolin and cyanidin may also be common.

158. On the natural coumarins present in *Heracleum concanense*.

P. K. Bose, Calcutta.

The fruits of the umbelliferous plant, *Heracleum concanense*, growing wild in Western Ghats, have been found to contain a mixture of natural coumarins, from which bergapten has so far been isolated and identified.

159. Attempts to synthesize 2-methyl-4-propyl pyridine.

R. H. Siddiqi, Aligarh.

2 : 6-Dimethyl-4-propyl-1 : 4-dihydropyridine-3 : 5 dicarboxylate, m.p. 122-123°, on oxidation, gave 2 : 6-*dimethyl*-4-*propyl pyridine* 3 : 5-*dicarboxylate*, b.p. 244–250°, picrate, m.p. 90-91°. This dicarboxylate was hydrolyzed and the product so obtained was decarboxylated when it gave 2 : 6-*dimethyl*-4-*propyl pyridine*, b.p. 193–195°, picrate, m.p. 81-83°, aurichloride, m.p. 150°, platinichloride, m.p. 225°, methiodide, m.p. 175°. The trialkyl pyridine on condensation with benzaldehyde gave 2-*styryl*-4-*propyl*-6-*methyl pyridine* and 2 : 6-*distyryl*-4-*propyl pyridine*. Both these derivatives gave well-defined salts.

160. Chemical examination of the roots of *Rauwolfia serpentina*.

R. H. Siddiqi, Aligarh.

A new base ajmalidine has been isolated from the roots of *Rauwolfia serpentina*. It belongs to the bases of the ajmaline series. Further work is in progress.

161. The non-alkaloidal constituents of the root-bark of *Tabernamontana heynea*.

K. Sreedharan Nair *and* P. P. Pillay, Travancore.

This low-growing tree commonly found in Malabar is used in indigenous medicine as an anthelmintic and for diseases of the eye. Besides reducing sugars, resin acids, etc., the root bark contains, rubber 0·44%, sterols 0·13% which have been separated into a liquid sterol and two crystalline sterols melting at 162° and 183°C., total alkaloids 1·1% and ash 25·5%. The sterols were separated by their differential solubility of the acetylated product in acetone and alcohol and characterized by several derivatives. The ash consists mainly of K, Mg, Ca, Fe, Mn and SiO_2, P_2O_5, SO_4, Cl and CO_3. The alkaloids are under investigation.

Biochemistry

162. Chemical nature of insulin.

C. N. Bhima Rao, N. N. De, M. V. Lakshminarayana Rao, M. S. Ramaswami, *and* V. Subrahmanyan, Bangalore.

Insulin is generally described in literature as the '*p*H 5·0 protein' of the pancreas which is further characterized by its high sulphur content. This protein is now available in crystalline form and carries an average potency of 22·5 International Units per mg. This would suggest a definite chemical composition and structure though preparations possessing many times the above potency have, from time to time, been reported.

We have recently isolated '*p*H 5·0 protein' in the following manner. Fresh (or recently frozen) beef pancreas was ground with sand and extracted with dilute HCl the effective concentration being about 0·04*N*. The extract was then dialyzed against running water for a few hours followed by separation of the precipitate by centrifuging. The precipitate was dried *en vacuo* and then extracted with acetone. The residue was extracted with $N/200$ HCl and the extract fractionally precipitated. The pH 5·0 protein which was the largest was dissolved, dialyzed and the resulting precipitate dried.

The final product was quite white and had all the physical and chemical properties of standard insulin. It had also the same sulphur-nitrogen ratio, *but it did not possess any hypoglycemic activity.*

The available evidence would show that the hypoglycemic principle is a substance carried predominantly on the pH 5·0 protein, but the protein itself is inactive.

In the methods usually employed for the preparation of insulin, the use of volatile solvents, the avoidance of prolonged dialysis and a few such details help to extract and to preserve the active substance along with the protein, but the harmone is a distinct entity and should be separable under favourable conditions.

163. Purification and chemical nature of rennin.

C. N. Bhima Rao, M. V. Lakshminarayana Rao, M. S. Ramaswami, *and* V. Subrahmanyan, Bangalore.

Rennin, approximating to the integrally pure form, was prepared from calf stomach mucosa in the following manner. The mucosa were extracted for 24 hrs. with 0·04N HCl followed by dialysis for 6–8 hrs. against running water when a mucilaginous precipitate containing the major part of the activity settled down. The precipitate was centrifuged out and then successively extracted with increasing strengths of dilute acid (commencing from 0·01N HCl) and the extracts adjusted to pH 5.4 when the major part of the associated proteins and other impurities separated as a precipitate while the bulk of the activity passed into the water-clear supernatant. Extracts containing the smallest amounts of nitrogen (*Ca* 1-2 μg) per unit of activity (a unit clotting 10 ml. of 30% solution of dried milk at pH 4·6 and 37° in 1 min.) were selected and further purified by short period dialysis and successive adsorption on specially prepared tricalcium phosphate at pH 3·5 and dissolution of adsorbent in dilute acid when nitrogen-free products retaining the major part of the original catalytic activity were obtained. The preparations were also free from phosphorus, sulphur, pepsin and carbonic anhydrase. The above observations would come in striking contrast to the earlier reports in literature which describe rennin as a protein or proteose containing over 14% nitrogen together with varying amounts of sulphur and phosphorus. The properties and behaviour of rennin at various levels of purity have been studied and will be shortly described in a detailed paper.

164. A thermostable component of rennin and its replaceability by zinc.

C. N. Bhima Rao, M. V. Lakshminarayana Rao, M. S. Ramaswami, *and* V. Subrahmanyan, Bangalore.

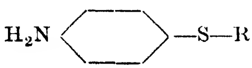
On standing for varying periods of time in the region of pH 6·2–6·8 rennin undergoes inactivation, the rapidity and extent of such inactivation depending on the purity of the preparation. A considerable part of the original activity can be restored on adding boiled enzyme, the extent of restoration depending on the activity before boiling. The thermostable component is present in the autolysate of mucosa (even after all the activity is destroyed) and is resistant to the action of strong acids as well as alkalies. It withstands evaporation but not strong ignition. It is readily dialyzable. The thermostable component is replaceable only by zinc in minute quantities. The degree of restoration of activity is proportional to the concentration of zinc, the maximum attained being practically identical with that attained on adding the thermostable component. Zinc is present at all stages in the purification of ronnin. This would suggest that the element closely similar to, if not exactly identical with, the thermostable component.

The above observation throws further light on the importance of zinc in nutrition—particularly in the feeding of infants who are exclusively on a milk diet. The significance of some of the well-known Indian remedies for treating infantile disorders (particularly enlargement of liver and spleen and allied complaints) also gain prominence as they contain mostly zinc oxide in a highly calcined form. The therapeutic value of ronnin (which also contains ascorbic acid in combined form) is under systematic study with the co-operation of hospital authorities and medical men.

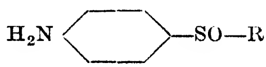
165. Chemotherapy of bacterial infections: sulphides, sulphoxides and sulphones.

DEBABRATA DAS-GUPTA, Bangalore.

Diphenyl-sulphide, sulphoxide, and sulphone, and their derivatives are known to possess pronounced antibacterial properties and high toxicity. So, the preparation of compounds of the following types have been undertaken.



(I)



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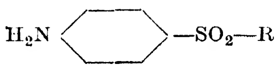

(III)

R, representing, thiazolyl, pyrimidine and other heterocyclic residues, which are expected not only to increase the antibacterial activities of the resulting compounds, but also to reduce the toxicity.

166. Crystalline vitamin B_1, from rice bran.

Y. V. S. RAU, Bangalore.

Vitamin B_1 concentrate has been prepared according to the procedure described above and crystalline vitamin B_1 isolated from it using silver-nitrate and silico tungstic acid as precipitants for vitamin B_1. The yield of crystalline vitamin B_1 has been low and factors affecting it are being investigated.

167. The mechanism of β-amylase inhibition by vitamin C.

P. SESHAGIRIRAO *and* K. V. GIRI, Waltair.

A critical study of the mechanism of β-amylase inhibition by vitamin C has been made. The hydrolysis of starch by the amylase is inhibited by vitamin C alone and vitamin C-Cu complex, the latter exerting greater inhibition. A variety of compounds—oxalic acid, uric acid, xanthine, guanine, theophylline, yeast nucleic acid, creatinine, cysteine, cystine, glutathione, histidine, potassium cyanide and hydrogen sulphide - which are shown to inhibit the catalytic oxidation of vitamin C by Cu, annul or prevent the inhibition and the inactivation. The oxidized products of the vitamin prepared by Cu oxidation also exert inhibition on the hydrolysis of starch by the amylase, and this inhibition also is annulled by the above compounds which act as stabilizers for vitamin C against oxidation.

In addition to the inhibition exerted on the hydrolysis, vitamin C-Cu complex and the oxidized products of the vitamin inactivate the enzyme in the absence of substrate. Vitamin C alone brings about very feeble inactivation of the enzyme. A suggestive correlation between the inhibition of the hydrolysis and the inactivation of the enzyme on the one hand, and the oxidation of vitamin C on the other, has been established. The physiological significance of these findings in their relation to the influence exerted by the purine derivatives and other stabilizers of vitamin C oxidation in regulating the activity of amylases in plant life, is discussed.

168. The inhibitory action of purines, nucleic acid and imidazole compounds on the oxidation of vitamin C.

K. V. Giri and P. Seshagirirao, Waltair.

The effect of purine derivatives, yeast nucleic acid and other compounds with imidazole grouping on the oxidation of vitamin C by Cu^{++} at pH 7·2 was studied both by manometric technique and titration with iodine. Among the purine derivatives, xanthine, guanine, uric acid, theophylline, and yeast nucleic acid exert complete protection against oxidation, while theobromine and caffeine have no influence. Creatinine, histidine and allantoin also exert protection and creatine has no effect on the oxidation.

Preliminary experiments have shown that the compounds which inhibit the catalytic oxidation of the vitamin have no influence on the enzymic and photo-chemical oxidations at similar concentrations. The possible mechanism of inhibition of vitamin C oxidation by the compounds is discussed. The results suggest that the purine derivatives and nucleic acids may play a very important rôle in stabilizing the vitamin against oxidation in plant and animal tissues.

169. Oxidase system in *Solanum melongena*.

K. V. Giri and P. Seshagirirao, Waltair.

It is well known that *Solanum melongena* undergoes rapid browning and discolouration when the cut surfaces are exposed to air. The mechanism of this discolouration has been studied and in the course of investigation it was found that it contains an oxidase system which oxidises catechol and p-cresol. The nature of the oxidation of these two compounds has been described. The instability of the enzyme system prevented its purification by ammonium sulphate precipitation, and acetone precipitation. Even dialysis is found to considerably inactivate the enzyme. Catechol is found to act as carrier in the oxidation of ascorbic acid by the enzyme system. The discolouration may be due to the catalytic oxidation by the oxidase system, of the natural polyphenols occurring in the vegetable.

170. The extraction of estrogen from plant material and the chemistry of estrin.

R. Lobo-Mendonca, Bombay.

White rats are ovariectomized by the lumber route, ether being used as anaesthetic. Care is taken that no ovarian tissue is left behind by removing not only the ovaries but also the fatty tissue round about them and a part of the fallopian tubes on either side. After an interval of ten to twelve days the vaginal epithelium degenerates, and the vaginal smear shows leucocytes only. An estrin preparation is injected into each rat, and only those rats which give a positive reaction as shown by the presence of eosinophilic scales are chosen for the experiment. The roots, stems and leaves of *Butea Superba* and *Butea Frondosa* were first extracted with alcohol. The alcoholic extract was purified according to the methods of Allen and Doisy and also by a method suggested by Marrian and then injected into the above ovariectomized rats. The potency of these extracts was tested by taking vaginal smear after the lapse of 24 hours following the administration of the injection. False reactions due to want of vitamin 'A' or to swabbing were guarded against by administering cod-liver oil and careful handling of the rats.

171. Schiff's bases from sulphanilamide derivatives.

U. P. BASU, Calcutta.

As drugs of sulphanilamide group are generally sparingly soluble in water, difficulty often arises during treatment with these drugs when the patients cannot take them by mouth or when rapid effect seems to be essential. Various soluble derivatives have already been prepared from one or other compound of this group. In the present paper certain Schiff's bases have been prepared from sulphanilacetamide which is being found to be efficacious against gonococcal infections. These are expected to afford the desired soluble salts.

The sulphanilacetamide has been condensed with *p*- and *o*-hydroxy, *p*-dimethylamino-, *p*-nitro-, and pure benzaldehyde. These are light yellow to red crystalline powders insoluble in water. The corresponding Schiff's base from cinnamic aldehyde on treatment with sodium bisulphite solution afforded a white crystalline powder readily soluble in water. Work is also in progress to convert all the bases to soluble varieties and to test their pharmacological characteristics.

Analytical Chemistry

172. Transposition of the insoluble phosphates by means of alkali carbonates and peroxides.

P. D. SWAMI, Bikaner.

In the qualitative analysis of a mixture of substances the presence of phosphates, oxalates and fluorides generally causes interference in the regular scheme of analysis. In the analysis of the mixtures, containing salts of rare elements such as Ce, Zr, Th, U, etc., along with the phosphoric acid, it is found that none of the methods which are commonly in use gives satisfactory results. Another method is, therefore, suggested for the separation of the phosphoric acid by some workers but no quantitative data are given by them. According to this method a phosphate is treated with Na_2CO_3 solution and some Na_2O_2 by which it is transformed into insoluble carbonate and soluble alkali phosphate.

From the results obtained from the numerous experiments, which are given in the paper, the following conclusions are drawn:—(i) The iron phosphate undergoes a complete transposition. In the case of the strontium phosphate the transposition is above 90%. (ii) The addition of Na_2O_2 increases the percentage of transposition to a marked extent, its effect on the calcium and strontium phosphates is, however, not very striking. (iii) The effect of the various concentrations of the Na_2CO_3 solution is to increase the percentage of transposition of the phosphates. (iv) The phosphates when Na_2O_2 is added are transposed very nearly to completion. (v) With the increase in the solubility product of the phosphate the transposition is effected to a lesser extent.

In the qualitative analysis phosphoric acid can effectively be eliminated only by treating the mixture with a large excess of Na_2CO_3 and some Na_2O_2.

173. A new method for the estimation of small amounts of water in absolute alcohol. Part II.

N. VENKATANARASIMHACHAR, Bangalore.

The solubility of sodium chloride in alcohol containing different amounts of water has been determined at 29°C. Considerable changes in the solubility has been noticed. This method can be conveniently adopted for the determination of small amounts of water in absolute alcohol.

174. Estimation of zinc in milk.

M. R. ASWATHA NARAYANA RAO, Bangalore.

The ferrocyanide method, that is generally employed in the estimation of zinc in foodstuffs, cannot be employed in the case of milk when small quantities of milk are available. The estimation of zinc in milk is particularly important since it is generally believed that zinc difficiency brings about infantile cirrhosis. The colorimetric method for the estimation of zinc, using diphenyl thiocarbazone, has been developed to estimate zinc in milk. Details of the analytical procedure are given. This method can be employed to estimate even traces (0·001 mg. per c.c.) of zinc.

175. Conductometric determination of the conversion of chromates into dichromates.

G. N. KADHE *and* N. L. PHALNIKAR, Poona.

Previous methods of estimating chromates in presence of dichromates depend on (i) the measurement of absorption spectra, (ii) potentiometric, and (iii) titration of the chromate with sulphuric acid using congo red as indicator. We have followed the change of chromate into dichromate by addition of sulphuric acid by measuring the electrical conductivity of the solutions. The method is useful in determining the conversion of chromates into dichromates in presence of sodium carbonate and sodium hydroxide.

176. Alcoholysis of oils and fats.

K. N. RAHALKAR *and* S. K. K. JATKAR, Bangalore.

A simple method of following the rate of alcoholysis of oils and fats has been developed by noting the increase in weight of the non-volatile products of alcoholysis. Sulphuric acid has been found to be far more active than hydrochloric acid, the retarding influence of water being far less with the former catalyst than with the latter.

177. A modified method for the estimation of lactic acid in bacteriological culture fluids.

S. L. VENKITESWARAN *and* M. SREENIVASAYA, Bangalore.

The method of Friedemann and Graeser has been modified, employing steam to distill over the acetaldehyde formed by the oxidation of lactic acid with dilute permanganate. By replacing their Kjeldahl flask with a Dewar's vessel, the condensation of steam in the reaction vessel is avoided and the necessity of boiling the reaction mixture eliminated. The employment of steam as the distilling agent has the additional advantage of facilitating the rapid removal of the aldehyde and also its absorption by the bisulphite. With the apparatus that has been designed by us, it is possible to carry out a series of determinations in a single assembly. A sketch of the apparatus and the accuracy attainable by this method are described.

178. Examination of the nature of soil organic matter by chemical oxidation processes.

S. P. RAYCHAUDHURI *and* ABDUL BAREK BHUIAH, Dacca.

Attempt has been made to find out the nature of the organic matter of some soil samples by determining its rate of oxidation by alkaline permanganate, acid potassium permanganate and acid potassium dichromate solutions. The temperature of oxidation was kept constant throughout with the help of a thermostat. It has been found that the organic matter of the soil is oxidized by different oxidizing agents in the different soil samples in similar orders.

Industrial Chemistry

179. Cold moulding compositions from Kiri and refuse lac distilled oils.

H. K. SEN, Ranchi.

The incorporation of drying oils with Kiri and refuse lac distilled oils and their vulcanization with sulphur have given rise to stoving enamels of improved properties, particularly as regards gloss, adhesion, elasticity, hardness, water and acid resistance. This varnish when mixed with fillers like asbestos, cotton waste, jute waste, etc., after suitably thinned with equal parts of turpentine and kerosene oil and well kneaded on hot rollers has given compositions of good flow for cold mouldings. Such cold moulded articles after being sufficiently baked are found to be resistant to heat, water, acid and alkali. Considerable success has already been obtained in this direction.

180. Modification of lac and lac constituents for improved varnishes, adhesives and moulding powders.

H. K. SEN, Ranchi.

(*a*) Interaction of unsaturated dibasic acids like maleic, fumaric, etc., with shellac, shellac acids, aleuritic acid ester, etc., followed by the action of organic peroxides, e.g. benzoyl peroxide, has given rise to resins of extraordinary adhesive properties and basic material for the manufacture of safety glasses, plywood bonding, laminated boards, etc. The resins could also be used for preparing moulding powders capable of moulding both by cold and hot processes. Attempts are also being made for making cast resins from some such modified compositions.

(*b*) The shellac formals obtained by heating shellac with formalin or paraformaldehyde when treated with urea and fatty acids of oils in presence of higher alcohols have given resins of high water resistance, soluble in hydrocarbon solvents alone or in a mixture of alcohol and hydrocarbon solvents. The resin solution dries quickly giving an extraordinary glossy film and a short baking at 80°–100°C. for about half an hour makes it perfectly resistant to water. Paper, cloth, etc., when coated with such a solution either by dipping or brushing and dried, possess very good elastic and adhesive properties. The use of such coated materials in many electrical industries is suggested.

181. Oil-dressed fabrics.

H. K. Sen, Ranchi.

Among the many processes for water-proofing fabrics, impregnation with drying oils gives the most satisfactory products as regards durability, water-resistance and lightness in weight. Further, the process lends itself to easy gas-proofing as the film of the dried oil is more elastic than those from waxes, bitumens, etc. When a natural resin like shellac is incorporated in linseed oil, additional resistance to poison gases and petroleum are imparted. A similar improvement can also be brought about by following up a coating of a drying oil on cloth with a thin shellac spirit varnish. The distinctive features of the two processes are discussed in this paper.

182. A simple method of preparing pure resin from shellac.

S. R. Palit, Ranchi.

The usual method of preparing pure resin by ether extraction in a Soxhlet apparatus is very laborious, lengthy and troublesome. Other methods so far proposed are attended with various difficulties. It has been found that ethyl acetate can extract out almost completely the soft resin from shellac in a single operation at room temperature leaving the pure resin as a curdy, opaque, easily filterable, swollen mass. The loss of pure resin is very little if the solvent and the resin are fairly dry. A laboratory method has been devised on this basis, which has been found to give satisfactory results with a comparatively large quantity of shellac in a very short time. The same method is useful for commercial purpose and the cost of solvent can be cheapened by using a mixture of equal volumes of benzene and ethyl acetate. The product is quite satisfactory and the method is practically free from solvent recovery and filtration difficulties.

183. Gumoleo-resin *Boswellia Serrata*.

M. N. Goswami, Calcutta.

The physical and the chemical properties of the oil, resin and the gum from the gum-oleo-resin *Boswellia Serrata* were carefully examined.

The sp. gravity and sp. rotation of the oil were found to be changing with time. The sp. gr. and the sp. rotation of the steam distilled oil were found to be decreasing with time, whereas when the oil was fractionated into two portions the sp. gr. of the first fraction were found to increase with time when the sp. rotation was found to decrease. This change was very sharp with the high boiling fraction. Moreover, it has been found that the oil from different varieties has different physical and chemical properties. The conditions in which the oil is separated from the oleo-resin has greater influence on the physical properties of the oil. The physical and chemical properties of the resin, gum and the oil obtained by vacuum distillation from the resin were carefully examined.

184. Co-ordination compounds: Lakes from Chrome Fast Yellow 5G and Chrome Fast Violet B.

K. G. Kudva *and* K. Venkataraman, Bombay.

Chrome Fast Yellow 5G (disodium salt of 6-sulpho-β-naphthalene-azo-salicylic acid) gave a salt from its aqueous solution on treatment with nickel nitrate, chloride or sulphate. The nickel in the dye salt was ionized and could be precipitated by dimethylglyoxime. The salt was very sensitive to the action of mineral acids, which removed the nickel and gave dye acid, and the nickel was also entirely replaceable by barium.

With cobalt and copper sulphates the salts of the dye were similarly obtained. With cuprammonium sulphate and aquopentammine cobaltic chloride the respective inner complexes were produced. The copper lake had the formula $\left[\frac{3Cu}{2}(C_{17}H_9N_2O_6S)\,2H_2O\,.\,3NH_3\right]$ and of the 3 molecules of ammonia one was lost on drying, together with 2 molecules of water; but the 2 molecules of water returned on keeping in air. The dye gave with ferric chloride a lake with 4 molecules of water. On desiccating 3 molecules of water were lost, the lake apparently undergoing a modification in structure.

Chrome Fast Violet B (sodium salt of 2-hydroxy-5-sulphobenzene-azo-β-naphthol) yielded two nickel lakes, depending on the conditions of the reaction. With a large excess of a cobalt salt the dye gave a simple salt. Cobalt therefore did not have a characteristic lake forming tendency with this dye, unlike nickel, copper, iron and chromium.

185. Co-ordination compounds: Lakes from 1-nitroso-Naphtol AS.

K. G. KUDVA *and* K. VENKATARAMAN, Bombay.

The use of nitroso phenols or orthoquinone oximes has been more or less confined to calico printing, for which, however, they have the disadvantage that the iron lakes are dull in tone. The nitroso derivatives of Naphtol AS and its analogues appeared to be of special interest in view of the likelihood of lakes of enhanced brightness being obtainable from them. On account of the marked substantivity of the Naphtols in comparison with β-naphthol, due to the introduction of the carboxyamide group, their nitroso derivatives might have greater interest in dyeing cotton than dinitrosoresorcin and the nitroso naphthols. As in dyeing and printing, the Naphtols also possess the great advantage that they constitute a series of analogous derivatives of β-naphthol, in all of which the 1-position is free, so that a wide range of nitroso derivatives and lakes therefrom could be prepared.

The study of lake formation with quinone oximes has now been extended to the Naphtol AS series.

From the theoretical point of view, nitrosated Naphtol AS presented interesting possibilities. For example, the compound can act as a tridentate group like 1 : 2 : 3-triaminopropane, and can form a triple attachment to a single metallic atom. With a 6 co-ordinated metal atom two molecules of this compound can occupy the 6-positions in the co-ordination sphere. If, however, the molecule only acted as a bidentate it would require three molecules to occupy the 6-positions in the co-ordination sphere of the metal atom. It was found that only a single cobalt atom was associated with three molecules of the nitroso compound and a nickel atom with two molecules. These compounds were moreover fully saturated co-ordinatively. A ferric salt gave compounds of three different types, and the variations were due to the possibility of enolization of the carboxyl group in Naphtol AS (cf. Bhat, Forster and Venkataraman, *J. Soc. Dyers Col.*, 1940, **56**, 166).

Chromium had the tendency to show the same characteristics as iron in the formation of its lakes. Owing to the solubility of the chromium lake in alcohol, very poor yields of the products were obtained, and these were not of the same degree of purity as the iron compounds. With $\frac{1}{3}$ atomic proportion of chromium per molecule of the nitroso compound, the lake obtained invariably contained a higher percentage of chromium than would correspond with the $(R)_3Cr$ type lake. With a large proportion of chromium (1 atom per molecule of nitroso Naphtol) the lake formed was of the $(R)_3Cr_2$ type.

Copper formed a lake similar to the nickel lake. From nitroso Naphtol AS-GR, cobalt, nickel, copper and iron lakes were prepared and characterized.

186. Studies in indigoid dyes. Part I. 9 : 10-Phenanthrathiophene-naphthathiophene-indigos.

PARESH CHANDRA DUTTA, Muzaffarpur.

9 : 10-Phenanthrathiophene-2-thionaphthene-indigo was prepared by the author by the condensation of 9 : 10-phenanthrathiophene-2′ : 3′-dione with 3-hydroxy-thionaphthene (*Proc. Indian Science Congress*, 1938, 81). It is a violet dye and dyes cotton from alkaline hydrosulphite vat in violet shade. The present communication is a continuation of that work and deals with the condensation of 9 : 10-phenanthrathiophene-2′ : 3′-dione with isomeric naphthoxythiophenes such as 1 : 2-, 2 : 1-, and 2 : 3-naphthoxythiophenes. As expected, the condensation product with 2 : 3-naphthoxythiophene is deeper in colour than the parent substance 9 : 10-phenanthrathiophene-2-thionaphthene-indigo but although the molecular weight has been increased by the introduction of naphthalene ring in these naphthoxythiophenes for benzene ring of hydroxythionaphthene, the 1 : 2- and 2 : 1-naphthoxythiophene condensation products are lighter in colour giving only chocolate shades on cotton. This is in conformity with the findings of the author (*Ber.*, 1934, **67**, 1319; 1935, **68**, 1447; 1936, **69**, 2343), that the position of additional benzene ring in the thionaphthene nucleus has great influence on the colour of these dyes.

187. On preparation of Atebrin.

P. C. GUHA *and* S. P. MUKHERJEE, Bangalore.

Atebrin has been prepared by condensing 2-methoxy-6 : 9-dichloro-acridine (I) with 1-diethylamino-4-aminopentane (II). 2 : 4-Dichlor-benzoic acid has been prepared, starting from acetanilide via 2 : 4-dichloro-acetanilide, 2 : 4-dichloro-aniline and 2 : 4-dichlorobenzonitrile. 2 : 4-Dichlorobenzoic acid has been condensed with *p*-anisidine to give N-*p*-anisyl 4-chloroanthranilic acid, which, on treatment with phosphorus oxychloride, gave (I). The compound (I) and all the intermediate products have been obtained in good yields. The compound (II) has been prepared starting from diethylamine (also made here) in good yield, through the following stages:

$$\text{Diethylamine} \xrightarrow{CH_2Cl.CH_2OH} HOCH_2.CH_2.NEt_2 \xrightarrow{SOCl_2} Cl.CH_2.CH_2.NEt_2$$

$$Cl.CH_2.CH_2.NEt_2 \xrightarrow[\text{and subsequent hydrolysis}]{CH_3CO.CHNa.CO_2Et} CH_3CO.CH_2.CH_2.CH_2.NEt_2$$

$$CH_3CO.CH_2.CH_2.CH_2.NEt_2 \xrightarrow[\text{pressure, in presence of nickel}]{H_2,\ NH_3,\ \text{under}} \underset{\displaystyle NH_2}{CH_3.\underset{|}{C}H}.(CH_2)_3.NEt_2$$

(II)

188. Preparation of adrenalin.

P. C. GUHA *and* P. V. A. RAMAN, Bangalore.

The preparation of catechol which is the starting material for the preparation of adrenalin, has been attempted by two methods, viz. from *o*-phenolsulphonic acid and *o*-chlorophenol. By the application of the second method, viz. by heating *o*-chlorophenol with strong caustic soda solution at high temperature in an autoclave, a yield of 66% of catechol has been obtained on the weight of chlorophenol reacting: the amount of unconverted chlorophenol recovered being 40%. Catechol condensed with chloro-acetic acid (also made here) in presence of phosphorus oxychloride to give chloroacetocatechol (yield 59%). The chloro-acetocatechol, thus obtained, is condensed with methylamine (also made here) to give methylaminocatechol (adrenelone); (yield 60%). This keto base is reduced electrolytically to adrenalin (yield 75%). Work on further purification of the base as also on its resolution into active form is in progress.

189. Antimalarials on synthesis of new compounds related to atebrin.

P. C. GUHA *and* S. P. MUKHERJEE, Bangalore.

In atebrin, the side chain (I) viz. δ-diethylamino-α-methyl-butylamine is attached to the carbon atom in position 9 of the acridine nucleus. It is well known that the presence of the methyl group in α-position of the side-chain (I) in atebrin is quite necessary, as the replacement of this α-methyl group by hydrogen results in considerable diminution of the antimalarial activity of the acridine derivative. It was, therefore, considered desirable to study the effect of introduction of different alkyl groups (particularly methyl) in the positions β, γ and δ on the antimalarial activity of the acridine compounds analogous to atebrin. With this object in view, in this part, acridine derivatives containing alkyl groups (Me, Et, Pr) in the β-position of the side chain (I) have been prepared.

$$\begin{array}{l} \quad\;\; \alpha \quad\;\; \beta \quad\;\; \gamma \quad\;\; \delta \\ -NH\text{-}\underset{\displaystyle CH_3}{\underset{|}{CH}}\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}N(Et)_2 \end{array}$$

(I)

190. Therapeutic agents derived from quininic acid.

P. C. GUHA *and* N. C. JAIN, Bangalore.

Quininic acid has been obtained in good yield from quinine isolated from Indian cinchona bark. The paper describes the action of different diethylaminoalkyleneamines on quininic acid and its derivatives.

191. Acetic anhydride and acetone.

P. C. GUHA *and* N. RANGASWAMY, Bangalore.

With a view to explore the possibilities of the production in India of acetic anhydride and acetone which are substances of great industrial importance, the pyrolytic decomposition of acetic acid vapour was studied in the presence of various catalysts. In a particular case acetone was obtained in a yield of 50%. Further work is in progress.

192. Manufacture of ethylene and chemicals obtained from ethylene.

P. C. GUHA *and* AJOY GUPTA, Bangalore.

Ethylene, the parent substance for many industrially important chemicals, has been successfully prepared from alcohol by catalytic dehydration. Investigations have been carried out with a number of new as well as very cheap and easily available catalysts, and the optimum conditions found out. Some of these catalysts have been found to give a yield of ethylene as high as 90–96%. A semi-commercial apparatus was designed and successfully worked for the production of ethylene by the above method. The preparation of some commercially useful synthetic chemicals like ethylene dichloride and ethylene chlorohydrin starting from ethylene has also been successfully undertaken.

193. Chemical studies in the utilization of cotton-seed hulls. A rich source of furfuraldehyde and of potash.

P. Ramaswami Ayyar, Bangalore.

Among other constituents, the hulls on hydrolysis with dilute sulphuric and subsequent distillation, yielded as much 6·1% of clean furfuraldehyde. The ash of the hulls forming 2·3% consists mainly of potassium carbonate.

194. Flash points of some indigenous fatty oils.

P. Ramaswami Ayyar, Bangalore.

The following indigenous fatty oils on being heated carefully in an open nickel crucible with a micro-burner emitted vapours which got spontaneously ignited at the temperatures shown against them severally: cocoanut oil (Cochin), 240°; gingelly oil (black seeds), 270°; linseed oil (Nagpur), 308°; groundnut oil (Bangalore), 310°; castor oil (Bangalore), 310°; cold-drawn tobacco seed oil (Guntur), 330°. The above data afford approximate indications of the suitability of these oils for use in laboratory oil-baths.

195. Utilization of oil seed cakes.

A. Krishnamurti *and* B. N. Banerjee, Bangalore.

With the closure of European markets for oil-seeds and cakes on account of the war the problem of disposal of these materials by oil mills has become difficult. The possible uses of the edible oil seed cakes are: (i) manufacture of a good flour which can be used as a protein food. Methods have been worked out to obtain a suitable defatted flour and has been used along with other cereal flours, i.e. wheat, corn, etc., to prepare bread, biscuits, small cakes, and chapatis. These preparations are found to be satisfactory. (ii) The isolation of vegetable protein for the manufacture of adhesives and plastics. A promising adhesive has been obtained from the same and investigations on the manufacture of plastic are under progress.

196. Preparation of compound cattle feed.

J. L. Sarin *and* I. S. Kuckreja, Lahore.

A compound cattle feed in the form of pressed cubes has been prepared from oil-seed cakes of cotton and rape-seeds. The other raw-materials used are rice husks and wheat bran, etc. Molasses is the binding material. This feed was sent to Imperial Veterinary Research Institute, Izzatnagar for test and evaluation. Its chemical composition was found out to be moisture 7·60%. Percentage composition on dry basis is crude protein 21·05; crude fibre 13·91; ether extract 7·85; ash 13·85; nitrogen free extract 43·34; lime (CaO) 0·66; phosphate (P_2O_5) 1·57.

The feed was reported to compare favourably with the usual type of concentrates of recognized food value. Moreover, as molasses is incorporated in it, the product should be highly relished by cattle and might also act as an appetizer.

197. Study of the mechanism of production of ammonium chloride at Kaithal (Punjab).

J. L. SARIN *and* B. S. KAPUR, Lahore.

Production of ammonium chloride from indigenous raw materials is carried out at Kaithal, Punjab (Sarin, *Science and Culture*, 1941, **VII**, 107). The mechanism of the process was not understood and with a view to study it, a large number of samples of clay and town refuse (the two materials from which ammonium chloride is obtained) were collected and analyzed. It was found that percentage of ammonia in clay varied from 0·002% to 0·038% and in town refuse from 0·0063% to 0·009%. Further work is in progress.

198. Gram-shellac plastics.

J. L. SARIN *and* I. CHAUDHRI, Lahore.

The plastic prepared by us from gram-shellac had a higher percentage water absorption than phenol-formaldehyde plastics. Attempts were made to reduce this value. Various materials were tried. Best results were obtained by the addition of specially treated Cashew nut shell oil. This gave water absorption value of 6 to 7%. It was, however, noticed that while the addition of Cashew nut shell oil reduces the water absorption considerably, the impact strength was decreased. Further work is in progress with a view to overcome this difficulty.

199. Production of emery cloth and paper.

J. L. SARIN, Lahore.

The industry of sandpaper manufacture was started for the first time in the country as a result of the work done at the Government Industrial Research Laboratory. The problem of production of emery cloth and paper has now been studied and suitable indigenous raw materials have been located, and processed for the purpose. It has been found that proper grinding of the abrasive is important, and the preparation of the backing (paper or cloth) used in manufacture requires special attention. For grinding roller type mills have been found most suitable and for the backing, cloth back, filled by materials with starch base, is necessary. Both cloth and paper are now turned out in commercial quantities, and are used by Railways and other Civil and Military Departments.

200. Industrial utilization of saponine.

J. L. SARIN *and* M. L. BERI, Lahore.

Saponine prepared from soapnut (*Ind. & Eng. Chem.*, 1939, **31**, 712) has been used in the preparation of a number of industrial products of which the most important are foam stay for aerated drinks and foam solution for foam type fire extinguishers. The foam stay has been prepared by using saponine (1 lb.), glycerine ($\frac{1}{2}$ gallon) and water ($\frac{1}{2}$ gallon) while the composition worked out for the fire extinguishers forms the subject-matter of a patent. Both the products were sent to users for trial and have been well reported upon.

201. Production of artificial mineral teeth.

J. L. SARIN *and* K. K. NIJHAWAN, Lahore.

An attempt has been made to manufacture artificial teeth from indigenous ceramic materials. The raw materials used are kaolin, felspar and quartzite. Colouring oxides such as CoO, NiO, CuO and Cr_2O_3 are used to impart various tints to artificial teeth. For the preparation of teeth finely ground materials are intimately mixed and kneaded and the mass is then pressed into shape. The dried teeth are biscuited at 700°C., glazed and fired at 1250°C. in a coal fired kiln or an electric furnace. The following limits were found for compositions of the body-mixtures: kaolin 30 to 55%; felspar 35 to 50%; quartzite 30 to 60%.

The physical properties of the artificial teeth prepared, such as impact strength, cold crushing strength, acid resistance and translucency are being studied in comparison with those imported from abroad.

202. Utilization of Ajwan oil after removal of thymol.

P. S. VARMA *and* K. P. KARANTH, Benares.

It has been suggested that thymol and menthol can be manufactured from *p*-cymene provided the cost of *p*-cymene is low. Ajwan oil after removal of thymol has been found to be very rich in *p*-cymene and it has been possible to recover it in a very good yield in a state of high purity. The method adopted for the purpose is described in the paper.

203. Preparation of ionones from lemon grass oil.

P. S. VARMA *and* K. P. KARANTH, Benares.

The object of this investigation has been to prepare ionone from the raw materials available in this country, to minimize the cost and time of preparation and to study the influence of certain condensing agents, such as sodium ethylate, bleaching powder, aluminium chloride and caustic soda. A very exhaustive set of experiments has been carried on and exact procedure and proportions of condensing agents have been found out which would give the maximum yield of pseudoionone from the raw materials available in this country. Ionones have been prepared from pseudo-ionone with the help of different reagents and under different conditions and the yields obtained compared. A method has been developed by which ionones can be obtained in a good yield directly from lemon grass oil, and which can be conveniently employed for manufacturing ionones on a commercial scale.

204. Studies in the preparation of carbon rods.

H. K. JOSHI, Benares.

More than 60% of the cost of the raw materials constituting a '*dry cell*' is represented by expenditure in respect of the '*active manganese*', sheet zinc, and the carbon electrodes. Since at present there is no other alternative but to use imported zinc, the last two items have naturally attracted the attention of workers as to whether these can be obtained from indigenous source. Work relating to '*active manganese*' have been already reported from these laboratories. The present paper reports the results of two series of attempts in regard to the preparation in India of carbon rods which are of extensive importance. In the first instance, attempt was made to prepare the rods by use of a specially designed small brass mould which worked satisfactorily within certain limitations and with special precautions as to lubrication, application of the pressure and the disposition of the mould. Experiments also consisted of varying the proportions of pitch and tar, employed both separately and in mixture, as a binding material for the charcoal powder. In the second place, coke was substituted for charcoal. The pencils obtained after firing between 800–900°C. for 8–10 hours, when measured in regard to their apparent densities and conductivities compared favourably with the market samples. But the simplicity of the design and the mode of working with this mould was attended with certain limitation in regard to the length of the pencil which amounted only to 6 cm. Besides, the formation on the mould groove rendered the subsequent 'refilling' heterogeneous.

The attempts at overcoming some of the above difficulties resulted in the design of an extrusion type screw press operating two pounds of mixture at a stretch. This was kept warm and homogeneous by surrounding the cylinder with a molten paraffin bath. The extrusion pressure was about one ton weight. Fairly good pencils were obtained when the temperature of the bath was kept within 200–250°C. At a higher temperature, a part of the pitch decomposed and the liberated gases rendered the rods spongy and therefore, comparatively poor in conductivity. Experience had shown that a diminution in the proportion of the pitch and tar would definitely improve the quality of the resultant pencil. Any substantial reduction in the proportion of the tar entails an increase in the corresponding extrusion pressure which is in excess over the mechanical strength of the present unit. Further work is in progress with higher extrusion pressures.

205. Studies in the 'graphitization' of powdered coke.

N. R. Lele, Benares.

This work was undertaken for the determination of the optimum conditions for the preparation of carbon electrodes. The efficiency of one of the final stages of this process ('firing') is usually indicated by rise in the electrical conductivity. It is presumed that this change might be dependent on the degree of graphitization induced in the material during 'firing'.

Several series of experiments were carried out in which definite amounts of charcoal (abandoned after preliminary experiments as it was found unsuitable) and coke were subjected to arc discharges for varying periods. A graphite crucible containing the powder served both as a container and as a cathode. The following substances were admixed with the coke powder to serve as catalysts: ferric oxide, aluminium oxide and boron oxide. Whilst insipient graphitization was indicated, a detailed examination under the microscope revealed that the exposed material had appreciable 'inclusions' of the ashy residues produced chiefly on account of oxidation due to exposure to the atmosphere. Further work is in progress using arc discharges under vacuum and in an atmosphere of hydrogen and inert gas.

206. Further studies in the preparation of carbon electrodes with special reference to the '*binding*' and the pre-'*firing*' stage.

N. R. Lele, Benares.

Of the two available methods, viz., moulding and extrusion, the latter was found to be the best adapted especially for preparing small size carbons. A third method, viz., a combined moulding-extrusion device was developed and was found to serve fairly satisfactorily the needs of an experimental unit. Detailed experiments show that sugar syrups and gelatin were found unsuitable as binding agents, friction and the consequent tendency to jam being the main difficulty giving rise to pencils of insufficient tensile strength. 'Montan-wax' was found to be more suitable as a binding material specially when mixed with pitch the optimum proportion being determined by trial. Special precautions were also necessary to ensure the optimum 'extrusion temperature'. Under these conditions the 'green' carbons showed a satisfactory structure.

Results of further work showed that it is necessary to distinguish between the groups of reactions which occurred during the 'firing' and its preceding stage. An elimination of moisture and of the volatile components constitutes the chief changes which have to be completed to a maximum extent before 'firing'. It is found that prolonged exposure at a low temperature about 50°C. *under vacuum* represents the optimum conditions. The resulting material possesses a 'set' and a compact appearance, and is then ready for the next stage, viz., 'firing'.

Low pressure has not been found to be helpful during this stage. Graphitization of the above material is considered to be the main reaction which is induced only at elevated temperatures. Within the limitations of the available equipment, the author has found that sufficiently satisfactory pencils were obtained with high conductivity, when a prolonged 'firing' was carried out at atmospheric pressure in the temperature range 750 to 850°C. Further work is in progress.

207. A proposed method for the semi-large scale preparation of hydrogen peroxide by heterogeneous hydrolysis of persulphuric acid.

D. N. SOLANKI *and* N. R. LELE, Benares.

Earlier work in these laboratories by Joshi, Solanki and Sheshadri has exphasized that in preparation of H_2O_2 from persulphuric acid active oxygen is lost chiefly at two stages: (i) thermochemically in the electrolytic product at the operative conditions of temperature and pressure, and (ii) during the high temperature hydrolysis.

This paper presents results of experiments which were carried out in order to investigate, in further details, the conditions under which loss of active oxygen in regard to (ii) may be minimized. It has been found that the reaction proceeds chiefly '*heterogeneously*'. A large ratio of surface to volume was, therefore, observed to be an important requisite. In modification of the earlier technique developed in these laboratories, a unit has been designed based on the above principle. It has been found that a considerable improvement results in the time rate of the distillation of hydrogen peroxide and also its net yield for a given input of persulphuric acid, by the adoption of this procedure. Data are submitted to illustrate this under different conditions.

208. Electrochemical preparation of potassium dichromate from Indian materials.

S. S. JOSHI, D. N. SOLANKI, *and* J. CHAUBE, Benares.

The best method for preparing $K_2Cr_2O_7$ is by electrolysis of fused potassium nitrate and chromite with iron electrodes. The present paper reports data in regard to the influence of the following factors: (i) composition of the fused mixture, (ii) current and C.D. at the electrodes, (iii) temperature, (iv) duration of electrolysis, (v) superimposition of A.C. on D.C., and (vi) addition of foreign substances or catalysts.

Results under (i) show that the current efficiency and yield per K.W.H. increase steadily with the quantity of chromite up to a particular limit and then slow down. (ii) By variation of C.D. it was observed that best yields were obtained with a current of 3 amp. Results under (iii) indicate that the current efficiency increases steadily with the rise of temperature (400°–700°C.). (iv) Regarding the duration of electrolysis best results were obtainable with 4 hours' duration. (v) Superposition of A.C. on D.C. during the electrolysis improves the yield considerably probably by lowering the oxidizing potential. Quite a large number of substances of various types were tried as catalysts under (vi) and their influence on the yield of dichromate studied. Na_2O_2, KF, $KClO_3$, KIO_3, Pd, KOH, Ag_2SO_4, etc., were found to be the best in descending order.

The rest were found to be less promising while agents like V_2O_5, CeO_2 were found to be detrimental or negative catalysts.

The main product of the electrolysis is potassium chromate, which is obtained after lixiviating the electrolyzed mass with hot water.

Considerable difficulties were experienced in the conversion of chromate, obtained as the result of electrolysis, into dichromate by sulphuric acid which produces HNO_2 from KNO_2 present, thereby reducing the dichromate to green chromium sulphate. This was prevented by adding sufficient urea to the solution prior to acidification to destroy the HNO_2 formed.

209. Utilization of (Indian) heavy spar for preparing soluble barium salts.

SARJU PRASAD *and* C. V. S. RAMALINGA SHASTRI, Benares.

It is well known that extensive deposits of Heavy Spar occur in several parts of this country. The relative abundance of Witherite and Alstonite ($BaCO_3$ and $BaCO_3$, $CaCO_3$) is poor. In view of the almost complete stoppage of imports in this line and the extensive demand for this material for several industrial purposes and especially its value as a war material, the present work was carried out in order to ascertain the optimum conditions for the chemical conversion of the crude spar. Experiments were carried out to study the reduction by (i) powdered charcoal, and (ii) powdered coke of barytes at temperatures varying from 900° to 1120°C. It was observed that 950° represents the optimum temperature, where as high as 92% conversion of the barytes into soluble barium salts occurs. Use of charcoal gives best result in the proportion of 1·0 mol. of barium sulphate to 4·5 mols. of carbon (charcoal). If, however, coke is used, instead of 4·5 only 4 mols. of carbon (coke) are required. The latter reaction was studied only at the highest temperature, viz., 1100°–1120°.

210. Production of pure alumina from heavy spar and bauxite through aluminate formation.

SARJU PRASAD *and* C. V. S. RAMALINGA SHASTRI, Benares.

It has been observed that under certain conditions of temperature and in some definite proportions, barium sulphate and bauxite interact to give soluble aluminates; most of the SO_2 escapes and Fe_2O_3, TiO_2, etc., occur amongst the precipitate. By mere filtration, therefore, it has been possible to separate the aluminates from the impurities and recover alumina from the filtrate by means of hydrolysis in a fairly pure state being especially free from iron, which is itself a great advantage. Subsequent work has shown that the equilibrium point in the above reaction is markedly favoured in presence of certain catalysts. Work is in progress to investigate in detail the relevant mechanism and the optimum conditions.

211. Recovery of titania from bauxite.

S. C. NIYOGY, Calcutta.

Indian bauxites are generally rich in titania. In the process for the manufacture of aluminium, bauxite is digested with concentrated caustic soda. The alumina goes into solution as sodium aluminate and is later precipitated as pure alumina and reduced electrolytically. The residue after caustic soda digestion is found to be rich in titania (using Indian bauxite) and an attempt has been made to prepare pure titania from this material for use as a white paint.

212. Criteria for deciding whether a wash is meant for illicit distillation or vinegar manufacture.

S. N. Chakravarti, B. R. Nautiyal, *and* M. B. Roy, Agra.

The indigenous method of manufacture of vinegar used in the United Provinces (the details of which were obtained through the help of the Excise Commissioner, United Provinces) is described and various methods of distinguishing between washes meant for illicit distillation and washes meant for vinegar manufacture have been critically studied. Sixty-three different sugary solutions (gur solutions, cane juice) were allowed to ferment without *the addition of any yeast* for a period of three months under conditions essentially similar to those used in the case of vinegar manufacture by the indigenous method, and it was found that in 20 cases the alcoholic strength went up to more than 10% of proof spirit, in 14 cases the strength varied between 5 and 10% and in 15 cases between 2 and 5% of proof spirit. A careful series of comparative experiments were also made. It is clear from these experiments that none of the methods for distinguishing between the two types of washes is absolutely reliable and that the prosecution of persons found in possession of washes only (i.e. in cases where no illicit spirit or implements of distillation are seized along with the washes) containing more than 2% of proof spirit may, in many cases, lead to serious injustice and that the circulars of the Excise Commissioners of several provinces on the subject require modification. It has been suggested that one of the best methods of fighting illicit distillers, who put up the plea that the wash was meant for manufacture of vinegar, would be to make the production of wash containing more than 2% of proof spirit, whether for the manufacture of alcohol or vinegar *without licence*, illegal.

SECTION OF GEOLOGY

President:—RAJ NATH, M.Sc., D.I.C., Ph.D. (Lond.)

Stratigraphy and Palaeontology

1. The age of the Vindhyans.

J. B. Auden, Calcutta.

The question of the age of the Vindhyans has been discussed by many workers. Regarded as Older Palaeozoic in the 2nd (1893) edition of the Manual, and accepted as such by Vredenburg, they were considered by Holland to be in the main, if not entirely, pre-Cambrian. Fox and the present writer suggested that the Vindhyans may extend in age from pre-Cambrian to Lower Palaeozoic. Recently, M. R. Sahni, in his interesting Presidential Address to the Geological Section of the Indian Science Congress, favoured a pre-Cambrian age. The object of this paper is to suggest that the case for a pre-Cambrian age for the whole of the Vindhyans cannot be regarded as proven.

Sahni objected that the fossils found in the Vindhyans are not like known Cambrian forms. He considered also that the Vindhyan rocks were suited for the preservation of fossils, and that the absence of recognizable Cambrian forms proved a pre-Cambrian age. In the writer's opinion, this view does not take cognizance of the fact that the Vindhyans are in the main a fluviatile continental formation, with only minor marine intercalations, and these more particularly in the Semri series (Lower Vindhyans). The Vindhyan fossils are found in the Suket shales, at the top of the Semri series, the lowest series of the System. Above the Semris are in places over 10,000 feet of mainly fluviatile sediments, the deposition of which must have taken a long time. Even if the known Vindhyan fossils are pre-Cambrian, the age of the overlying Kaimur, Rewah and Bhander series is not thereby proved to be pre-Cambrian.

The reason for the absence of fossils in the higher series is attributed by the writer to the fact that the migration of marine faunas and floras to fresh water and continental environments had not probably taken place as early as the Cambrian. He suggests that true marine conditions existed towards the north, in what is now the Salt Range, and Iran, and that it is in the rocks of these areas that the Cambrian faunas are found. Even in these known Cambrian rocks, the faunas are almost confined to the Neobolus shales, the conditions of deposition of the remaining facies having been apparently inimical to the existence of life. These conditions were partly connected with high salinity and partly perhaps with estuarine intercalations.

Similar conditions existed at this period in other parts of the Ur-Gondwana continent. The pre-Devonian Waterberg system of South Africa is also a continental formation, and devoid of fossils. It is regarded as most probably Lower Palaeozoic. The Nama system of western South Africa again closely resembles the Vindhyans, and is regarded as Cambrian, or latest pre-Cambrian.

The author does not accept a correlation of the Vindhyans with the Lower Haimanta of the Himalaya, which are lithologically totally different, and are more probably of Cuddapah age. The Himalayan equivalents of the Vindhyans may possibly be illustrated by the continental beds of Pulumsumda, on the Tehri-Garhwal/Tibet frontier, which overlie the

Haimantas, and also the Ordovician beds bordering the Nepal (Katmandu) valley.

In the author's opinion, the age of the Vindhyans should be regarded as extending from late pre-Cambrian to Lower Palaeozoic.

2. A note on the inter-trappean fossil beds of Chitanpalli-Naskal area in Pargi taluq of Mahbubnagar district, Hyderabad-Deccan.

C. Mahadevan, Hyderabad-Deccan.

Inter-trappean beds of marl, limestones and cherts containing fossils of Charophyta, wood, molluscs and fish remains occur in between two layers of Deccan Traps on the hill scarp between the villages of Chitanpalli (77° 53′ 48″ : 17° 16′ 24″) and Naskal (77° 52′ 24″ : 17° 13′ 36″) in Pargi taluq of Mahbubnagar district. These fossiliferous beds are about 25 ft. thick.

During an examination of these beds, it was found that there is zonal distribution in the fossils, one locality being rich in gastropods, another in lamellibranchs, and a third, in Charophyta. Some of the chert beds are richly studded with fossil Charophyta in which most of the species described in recent years from the inter-trappean beds of C.P. and Rajahmundri are recognized. The paper describes the geology of these inter-trappean fossil beds.

3. Note on the transition beds which occur between the Gaj and the Lower Manchhars in S.-W. Sind.

E. T. Vachell, Digboi.

Near, and to the south-east of, Karachi there occurs a series of sandstones and sandy shales the precise stratigraphical correlation of which was doubtful; and which had been referred to the Lower Manchhars by W. T. Blanford and correlated with the Hinglaj by E. W. Vredenburg.

Petrologically these beds show affinities to the Manchhars, but they contain fossiliferous beds with a Gaj fauna. Correlation with the Hinglaj (modern Mekran Series) is not tenable, since recent work by F. E. Eames has shown that the fauna of the clay group below the Mekran Series is not as old as that of the Gaj and that these clays are probably of Sarmatian age.

It appears that in the neighbourhood of Karachi the normal Gaj is overlain by a zone, probably of estuarine origin, in which interfingering occurs between marine beds of Gaj type and beds having affinities to the Manchhars. It seems that this interfingering began in late Burdigalian times and continued until Siwalik conditions were firmly established in Vindobonian times. Part of the zone of interfingering is therefore equivalent to the uppermost part of the Gaj and part is homotaxial to the basal Siwaliks (Kamlials) further north.

4. Note on the Tertiary sequence in Tripura State.

E. T. Vachell, Digboi.

The stages and substages of the Tertiary succession as established in Assam and in Arakan can be distinguished in Tripura State. The lowest rocks exposed are the Upper Bhuban Substage of the Surma Series; inliers of which, being more resistant to weathering than the overlying Boka Bils, give rise to the high ridges in eastern Tripura.

The folds in western Tripura do not expose rocks lower than Boka Bils, and some of the low rolls which are developed involve rocks of very high horizon and only just expose the Tipam Sandstone.

Investigation by F. E. Eames of fossils which were collected by K. L. Das, State Geologist to His Highness the Maharaja of Tripura, and which were kindly lent for examination, have confirmed the Lower Miocene age of the lowest beds exposed.

The paper concludes with a correlation between the subdivisions adopted by K. L. Das in his recent paper on the Tripura rocks and the standard Assam succession as described by P. Evans.

5. On the nature of the Blaini conglomerates.

K. P. Rode, Waltair.

The Blaini beds which were named after a stream of that name near Solon are primarily a series of conglomerates which are found usually associated with the Infra-Krols and Krols on the one hand and with the Simlas and Jaunsars on the other. These are best developed in the Simla-Sirmoor Himalayas and due to their great persistence and peculiar nature have been regarded as of great stratigraphic significance, firstly, in unravelling the sequence of formations and, in general, the structure and secondly in establishing the age relationships. In the absence of any fossil evidence the rock-formations—Infra-Krols and Krols—have been regarded Permo-Carboniferous in age, since the associated Blaini conglomerate has been correlated with the Talchir Boulder Bed owing to the supposed occurrence of glacial markings on the included pebbles.

The present author had opportunities of examining this boulder bed at several localities and he has failed to find any true glacial markings; moreover, the pebbles contained in the boulder bed, though dominantly of vein quartz and older quartzites, are not necessarily restricted to older formations, but he had observed pebbles of sandstone and shales which are of distinctly younger formations, e.g. Infra-Krols and Krols. In view of this the author is inclined to doubt the stratigraphic importance of a large proportion of these Blaini conglomerates. The author advances two possible modes of origin of a large proportion, if not of all, of the so-called Blaini conglomerates:—

1. As coarse river detritus accumulated after the first phase of Himalayan folding in longitudinal valleys which have been folded in during subsequent foldings.
2. As crush conglomerates during major thrust movements.

Both these modes of origin suggest a post-Eocene age and mark only certain stages in the Himalayan folding. The Blaini conglomerates, at least a large part of these, are thus no true stratigraphic units but are only tectonic formations.

6. A traverse through the Kewal Khala, Simla Hills.

K. P. Rode, Waltair.

Kewal Khala is an important stream flowing north-east along the western boundary of the Sirmur State and joins the Giri river near Dudham about 9 miles east of Solon. The stream follows a tectonic line of transverse anticline or culmination across the Krol belt. The stream thus gives a type section clearly exposing the whole Krol succession. The importance of this section had already been realized by previous workers, Pilgrim, West and Auden. During a recent visit a rapid traverse was made through this stream in which exposures of Jaunsars associated with the Simlas were distinctly recognized near Shatdhara, both of these formations being interpreted and mapped by these previous workers as Krols.

7. A new outcrop of Ostrea limestone bed at Mukurmatia, Mayurbhanj State, and its new fossil fauna.

B. H. Jena, Mayurbhanj State.

Different species of *Ostrea* and *Amphistegina* or *Rotalia* were described by P. N. Bose, Pilgrim, Tipper and Eames from a limestone bed at Mahulia, about 2 miles south of Baripada, the capital of the State.

A new outcrop of the limestone bed has also been discovered by the author at Mukurmatia, about 7 miles south of Baripada with its rich fossil content that, in addition to *Ostrea*, is characterized by the presence of fish and shark teeth, fossil crabs, fragmentary bones of vertebrates, lamellibranchs and gastropods.

Amongst the molluscs many of which have only been found as casts, the specific identification of *Cadium protosubrugosum* sp. nov. and *Nuculana virgo* K. Martin has been possible. Owing to the fragmentary nature of other fossils and a large number of shark teeth, it has not been possible even to assign a generic position to the majority of the fossils. But from the general faunal assemblage a provisional correlation with Pegu beds (Miocene) of Burma is suggested.

8. On the nature of underground strata as revealed by the tube-wells at Benares.

R. C. Misra, Benares.

The paper deals with the tube-wells in the Benares Hindu University grounds and those in the compound of Benares Water-works.

A geological study of the strata as revealed by the bore hole sections has been made.

The maximum depth of the wells is 258 feet and the minimum is 160 feet.

The water bearing horizons suitable for tube-wells are found below 130 feet of the ground level.

Clay beds are usually restricted to first 100 feet and sand beds are found between 125 feet and 200 feet below the ground level.

The occurrence of a bed of conglomerate about 3 feet in thickness is a common feature.

In one of the wells in which the length of the strainers is 68 feet and the diameter is 9 inches the yield of water is about 40,000 gallons per hour.

9. The age and derivation of Ceylon's Siwalik fauna.

P. E. P. Deraniyagala, Colombo.

The extinct large mammals of Ceylon which are known from isolated teeth and a few bones obtained from the strike valleys of the Ratnapura series, were originally (1936) considered to be of upper Siwalik Age, but recently have been regarded as younger than the Norbudda fossils of India (1940). Although this Ceylon Fauna is as much Siwalik as those of East Africa, Burma or Java, it differs in that its fossils are generally less mineralized while the matrix is seldom compacted. These features suggest that the Ceylon fossils are younger, although the dark grey colour of both fossils and matrix suggests that the process of fossilization is similar although less advanced. In Ceylon, features unknown from other Siwalik areas are the absence of equine and hyaena fossils and the association of a form of hippopotamus with *Elephas maximus* Linné, the most recent member of the Proboscidea; the possibility that some of the proboscidean molars belong to local subspecies of *Hypselephas hysudricus* (F. et C.) and to *Palaeoloxodon namadicus* (F. et C.), coupled with the occurrence of hippopotamus teeth of two distinct sizes and the discovery of fossils coloured yellow ochre, in association with dark grey ones, in one locality, all combine to complicate any attempt at correlating the Ceylon fossils with those from other Siwalik areas.

It is possible that in Ceylon, fossils of an Upper Siwalik horizon have been redeposited with bones of certain other Siwalik animals which persisted in the Island after Siwalik times. This view is supported by the varying degrees of their mineralization, while the central ring of steep waterfalls shows that the inner peneplane underwent an uplift which doubtless facilitated denudation of the older fossiliferous strata from the mountains with partial redeposition in the strike valleys.

The absence from Ceylon of many extinct animals common in other Siwalik areas, the presence of the hippopotamus which is unknown from South India, and the existence of a strong Malayan element and a lesser African one in Ceylon's living faunas, suggest the not impossible view that its Siwalik fauna did not enter direct via South India.

10. On the *Discocyclina* from the Eocene bed in the Pondicherry Cretaceous area.

L. RAMA RAO, S. R. NARAYANA RAO, *and* Y. NAGAPPA, Bangalore.

Since the discovery recently reported of an Eocene bed in the Pondicherry Cretaceous area (*Curr. Sci.*, Vol. 8, No. 4, 1939), the two leading types of foraminifers, *Nummulites* and *Discocyclina*, found in this bed are being studied. A brief account of the *Nummulites* was published some time back (*Curr. Sci.*, Vol. 9, No. 8, 1940), and in the present paper is given a description of the *Discocyclina*, from which it will be seen that this is what was previously described by Vredenburg as *Orbitoides minima* from this area.

11. Cretaceous orbitoids from the Ariyalur stage (Maestrichtian) of the Trichinopoly district, South India.

S. R. NARAYANA RAO, Bangalore.

Contains description of 3 species collected by the author and identified as follows: *Orbitocyclina ariyalurensis* sp. nov., *Lepidorbitoides inornata* sp. nov. and *Lepidorbitoides blanfordi* sp. nov. The orbitoids are confined to the Ariyalur stage (Maestrichtian) and are not present in the overlying Niniyur (Danian) strata as frequently stated.

The Ariyalur fauna is distinct from that described from N.W. India or Tibet. *Orbitocyclina ariyalurensis* and *Lepidorbitoides inornata* are remarkably close to forms known from Cuba.

The occurrence of the genus *Siderolites* in the Ariyalur limestones is also noted.

12. On the supposed Danian occurrence of orbitoids in India.

S. R. NARAYANA RAO, Bangalore.

In Europe, Cretaceous orbitoids are confined to the Campanian and Maestrichtian and are not known to occur in beds of Danian age. In India, however, some Danian occurrences have been reported; these are now discussed and shown to be based on erroneous data.

Review of evidences for assigning a Danian age is summarized as follows:—(1) Supposed occurrence of orbitoids in the Danian Niniyur beds.—Orbitoids are in fact confined to the underlying Ariyalur (Maestrichtian) beds. (2) Kossmat's record of *Orbitoides minima* from the 'post-Ariyalur' of Pondicherry.—*O. minima* is now recognized to be a *Discocyclina* and the bed containing it assigned an Eocene age. (3) Vredenburg's statement that *C. beaumonti* zone of Baluchistan includes part of the Maestrichtian with the Danian and that orbitoids occur in this zone.—*C. beaumonti* is wholly Danian and orbitoids of Baluchistan are confined to the *Hemipneustes*-beds. (4) Douvillé's record of *Lepidorbitoides* from the supposed Danian of Tibet.—The 'Danian' of Tibet is now referred to the Upper Ranikot age and the two species of *Lepidorbitoides* to Eocene genera.

There is thus no well-authenticated record of orbitoids in beds of Danian age—if this term be restricted to horizons characterized by *C. beaumonti* or *Hercoglossa danica*. Ranges for the several known genera in India are: *Orbitoides*—Campanian and Maestrichtian; *Lepidorbitoides*, *Omphalocyclus* and *Orbitocyclina*—strictly Maestrichtian.

The reported association of orbitoids with *Orbitolina* in India is doubtful, as the known range of the latter is Lower (Barremian) to Middle (Cenomanian) Cretaceous.

13. On a Cretaceous orbitoid from the Basal Laungshe shales of Burma.

S. R. NARAYANA RAO, Bangalore.

A Cretaceous orbitoid discovered by Dr. Cotter at the base of the Laungshe Series has been referred by him to a form described by Vredenburg (1908) from N.W. India under the name *Orbitoides apiculata* Schlumb. Vredenburg's species was revised by Douvillé (1916) to *O. vredenburgi* Douvillé and was described by him from the Campanian of Tibet. No details have so far been published regarding Dr. Cotter's important discovery from Burma.

Two thin sections of shale containing Dr. Cotter's species have been examined by me. The species is represented by several axial sections and one partial equatorial section which unfortunately does not give any idea of the embryonic chambers. Although the available material is inadequate for a precise identification, the species shows some structural affinity to *O. vredenburgi* and is more likely referable to the Tibetan species than to any other described from India.

The presence of a Cretaceous orbitoid in the Basal Laungshe shale is conclusive evidence of an Upper Cretaceous age (Campanian or Maestrichtian, but not Danian) for this bed. Regarding its bearing on the palaeogeographic history of the area, the question suggests itself whether the marine connection which existed between Tibet and Burma in the Lower Cretaceous was maintained in the Upper Cretaceous also. A more thorough study of the Laungshe orbitoid than has been possible with the present material is necessary before any satisfactory answer could be given.

The material studied is from the G.S.I. collections.

14. Calcareous algae of the sub-family Corallineae from a *Lepidocyclina*-limestone from the Andaman Islands.

S. R. NARAYANA RAO, Bangalore.

The following two species are described from thin sections prepared from material received from the G.S.I. collections: *Amphiroa oceanica* sp. nov. and *Corallina andamanensis* sp. nov.

The genus *Archæolithothamnium* is not present in the material studied by me and a species of this described and figured by Mr. Gee (1926) from the Andamans is believed to be from a much older horizon.

The associated foraminifera are identified as follows: *Lepidocyclina* (s.l.) sp. ind., *Amphistegina niasi* (Verbeek), *Operculinoides niasi* (=*Nummulites niasi* Verbeek of Vredenburg) and a form referable to the family Miogypsinidae. These indicate a late Oligocene or an early Miocene age.

15. A preliminary account of some calcareous algae from the uppermost Ranikot beds of Jhirak, Sind.

S. R. NARAYANA RAO, Bangalore.

The following genera are recorded from a study of thin sections of a limestone (from the G.S.I. collections): *Lithothamnium, Larvaria, Neomeris* and *Dactylopora* (?).

16. Palaeontological notes on Tertiary limestones of Travancore.

C. PRASANNA KUMAR, Mysore.

The paper embodies a description of a number of fossils from the limestones hitherto not reported. Some of these are new to science. Their identification reveal their similarity with contemporary fauna of Sind and Burma. The predominant forms bear an unmistakable Indo-Malayan aspect. From the above conclusion regarding the age of limestones is indicated.

Petrology and Mineralogy

17. On the perthites of charnockites.

P. R. J. NAIDU *and* M. S. SADASIVIAH, Bangalore.

The perthites of the charnockites of Pallavaram (the type area) have been described by Sir Thomas Holland as the 'Minerals with fusiform bodies'. These fusiform inclusions have been examined on the lines indicated by H. L. Alling. Measurements indicate that they are strings, stringlets and rods. Beads and plumes are absent. Their lengths are to 100. On 010 they appear as small circles or irregular polygons. The inclusions of charnockites, therefore, are ex-solution phenomena.

18. On the occurrence of harzburgites in Mysore.

P. R. J. NAIDU *and* M. G. C. NAIDU, Bangalore.

Fermor was the first to note the occurrence of Saxonite in the Zhob valley, Baluchistan. He also noted the presence of enstatite-diopside-olivine rocks in Salem. In this paper are studied the occurrence of such rocks to the north of the charnockitic range of hills (Nilgiri hills), near Holenarasipur, Mysore State. The harzburgites show a rare suite of chlorite minerals like kämmererite, etc.

19. Kyanite veins in gabbro, Mayurbhanj.

S. K. RAY, Calcutta *and* B. H. JENA, Mayurbhanj.

Kyanite was noted by Jena between two villages Gandipani (86° 38′: 22° 13′ 45″) and Kuldiha (86° 38′: 22° 14′ 30″) in N.E. Mayurbhanj adjoining Dhalbhum.

Petrographic studies by Ray shows that kyanite occurs in veins within gabbros, which are practically surrounded by gneisses. In the veins kyanite has cross-fibre arrangement and it is associated with actinolite-gedrite, clinochlore, quartz and sometimes tourmaline.

The gabbros are highly altered hydrothermally by solutions derived from the gneisses. The kyanite on account of its association and mode of occurrence, is regarded as deposited from these solutions.

The source of alumina has not been, however, definitely traced; but the presence of staurolite in a small inclusion of conglomeratic sandstone (about 10 sq. ft. in area) within the gabbro, is taken as an indication of its probable derivation from some metamorphosed aluminous sediments not yet discovered.

20. A note on the occurrence of some metamorphic minerals in Miryalguda taluq, Nalgunda district.

S. K. MUKHERJEE, Hyderabad-Deccan.

In the course of the geological survey of parts of Nalgunda district, a few localities were seen to be covered with surface spreads of corundum garnet, Vermeculites, as detrital materials.

The country is represented by granites, syenites, pegmatites, quartz veins and shredded patches of Dharwars.

The paper discusses the metamorphic changes affecting the rocks of the area giving rise to the above minerals.

21. Geology and petrology of the south-eastern part of Chur mountains, Simla Hills.

K. P. RODE, Waltair, S. L. BISHNOI, *and* R. S. SINGH, Benares.

During the mineral investigations in the Sirmoor State the authors had undertaken a detailed study of the geology and petrology of the south-western slopes of the Chur mountain. The geology of the area has been admirably mapped by W. D. West (1925–28) but the present study brought forth many new interesting facts of general tectonic importance which would justify a detailed mapping on a larger scale.

The area covered is about 15 sq. miles. The large collection of rocks made in the present investigation is being studied in the Geology Department of the Benares Hindu University. Some of the important observations made during the field work are:—

(1) The Chur granite is not a laccolithic massive *in situ* but is in the nature of a Klippe remnant of the Central Himalayan Nappe resting over the schists and quartzites of the Jutog Nappe.

A large part of the Chur granite is only schistose quartz porphyry traversed extensively by tourmaline pegmatites.

(2) There is a distinct zone of garnetiferous schist and quartzites occurring on the top of the western (Sitambu) ridge of the Chur over the granite and quartz porphyries with a clear northerly dip near Berog and Tisry camping grounds.

(3) There occurs a system of huge dolerite sheets generally showing transgressive relationships with the surrounding rocks. They are intimately connected with the Chur granite and quartz porphyries. Many new outcrops of dolerite sheet have been located.

(4) A new outcrop of the white saccharoidal limestone has been located near Chog Tali within a short distance of the granite. There is, however, no sign of contact metamorphism developed in the limestone. This rock is identical with the Jalag Didag limestone of the Carbonaceous Jutog Series.

22. Petrochemistry and provincial relationship of the eruptive rocks of Bhowali-Bhimtal area, Dist. Nainital, U.P.

K. P. RODE, Waltair, S. N. VERMA, *and* S. M. MATHUR, Benares.

The doleritic flows and sills known as the Nainital Traps occupy an area of over 30 sq. miles from Bhowali to the N.W. to Ranibagh to the S.E. The true field relations are somewhat obscure owing to the complex folding and thrusting which the area has suffered during Himalayan orogenesis.

In this paper is discussed the petrochemistry of the igneous suite which ranges in types from basic as dolerites and basalts through diorites to acid as granites, granophyres and quartz porphyries. The principal types were chemically analyzed and their analyses were interpreted on the Niggli methods calculating and comparing the kata and epinorm composition of the rocks with their modal composition. The normative feldspars and Pyroxenes as deduced from the rock analyses were also compared with the modal feldspars and Pyroxenes as determined by optical methods.

A study of the variation diagram on the basis of Niggli values has shown that all the different types of the eruptive rocks of this region have originated from the same magma through crystallization differentiation and that the trends followed during differentiation are those typical of the Circumpacific suites. These trends of differentiation are compared with other known suites of calc-alkaline nature and their nearest affinities are traced.

23. The probable relation between the Cuddapah trap sills and the post granitic dolerite dykes in Jatpol Samasthan, Hyderabad State.

L. S. KRISHNA MURTHY, Hyderabad-Deccan.

Interformational trap sills were seen associated with the basal members of the Cuddapahs between Kolhapur the capital of the Jatpol Samasthan (78° 19′ 30″ : 16° 6′ 30″) and Somsil (78° 19′ 49″ : 16° 2′ 20″), on the north bank of the Kistna river in Mahbubnagar district, Hyderabad State.

The doleritic trap sills are met with both above and below the limestone beds, overlying the basal quartzites. They are hard, fine to medium grained and weather into exfoliating boulders. The dolerite dykes occurring in the adjoining granite area show no indication of any surface continuity with the trap sills.

A petrological study, however, reveals a close resemblance between them. The paper discusses their mineral composition, microscopic character and other similarities and concludes that some at least of the post granitic dolerite dykes (Newer Dolerite dykes) are of Cuddapah age, the dykes probably representing the complement of the sills. The paper draws attention to similar conclusions arrived at by recent workers in the Singbhum area regarding the age of the sills in the sedimentaries and the dolerite dykes in the granite.

24. Kalang Rock, Khasi Hills, Assam.

N. N. CHATTERJEE, Calcutta.

The author had an opportunity of visiting the famous Kalang Rock (91° 33½′ : 25° 36′) situated in the Khasi Hills, Assam. This huge mass of porphyritic granite stands up boldly from the surrounding undulating country looking like a great dome of about 500 ft. high. It forms an exposure of the extensive granite batholith lying below the Shillong Plateau. The adjoining country is composed of fine grained streaky gneisses and schists covered with trees and thick grass in strong contrast with the naked and bare face of the Kalang Rock. This porphyritic granite is intrusive in the streaky gneisses and schists and shows signs of assimilation. The present paper deals with the general features of the porphyritic granite and the streaky gneisses in some detail. There are fairly big phenocrysts of pink felspar in the granite. The chief constituent minerals of the granite include felspar both microcline and oligoclase sometimes with perthitic intergrowth, quartz, biotite, hornblende, etc. The accessory minerals include apatite, zircon, sphene, iron oxide, ilmenite, etc. Zircon and apatite are sometimes found as inclusions in biotite, hornblende. Pleochroic haloes are found around the zircon inclusions in biotite. Myrmekitic structure is also present. Other petrological characters are enumerated in the paper. The structural features of the rock include several sets of joints and flow of phenocrysts. The more or less horizontal, and NNE/SSW vertical joints appear to be quite prominent and play important rôle in weathering and disintegration of the rock mass. The arrangement of the phenocrysts as observed possibly indicates a general flow of magma in a north-south direction.

25. Calc-granulites and amphibolites near Muri, Manbhum.

S. Roy, Calcutta.

Impure calcareous sediments, which have been metamorphosed under the influence of an intrusive granite-gneiss with addition of material from the latter to tremolite-diopside granite, garnet-diopside granulites, etc. have been observed near Muri (85° 52′: 23° 23′). The rocks form discontinuous lenticular patches invariably associated with sedimentary quartzites, with which they are conformable.

On the other hand there are dyke or sill-like masses of amphibolites in various grades of metamorphism, which are included in the granite-gneiss or which lie outside it.

No genetic relationship can be established between the two rock series, viz. calc-granulites and amphibolites. The amphibolites nowhere contain tremolite; calcite when present in them are secondary; the felspars are generally twinned; and diopside when present is secondary after the hornblende. They are nowhere associated with quartzite rocks. The amphibolites are sharply contrasted with the calc-granulites in every way. They are typical 'epidiorites' of Wiseman in the kyanite and sillimanite

26. Petrography of porphyritic granite-gneiss of Jhalda, Manbhum.

S. Roy, Calcutta.

In 1881 V. Ball mapped two sheet-like patches of porphyritic granite in Manbhum. One of these occupies a E.-W. belt of country about 4 miles wide stretching through Ledurka (86° 35′ : 23° 20′), Purulia (86° 27′: 23° 20′), and Jhalda (85° 52′: 23° 23′).

Recently the present author mapped a part of the country in detail and studied a portion of the granite and the surrounding rocks. The petrography of the granite only has been described here.

The granite weathers into typical domes. It is predominantly a porphyritic granite-gneiss, with primary foliation. The banding is in part due to *lit-par-lit* intrusion in the 'country'.

It is rich in microcline. The plagioclase shows a range in composition with 27% to 33% of An content. Several varieties have been recognized including mica-rich and hornblende-rich patches, which may be hybrid in part at least.

A petrographic description of the various types is given.

A non-porphyritic mass was analyzed chemically. It has the chemical composition of an adamellite.

27. On the rocks of the burnt coal outcrop from the Central Kujama colliery, Jharia.

N. N. Chatterjee *and* S. Roy, Calcutta.

Several specimens of fused sedimentary strata (sandstone and shale) were collected from the burnt coal outcrop of Central Kujama colliery lying in the Jharia coalfield. From field observation it is found that the specimens are connected with the outcrop of XI/XII seam of the Barakar Measures. The specimens are very hard and compact, dark green to black in appearance and have a cellular structure sometimes resembling a vesicular basalt. There are also several specimens which are highly cellular and friable. The paper gives a brief account of petrographic characters of these fused rocks. The fused mass consists of sillimanite-, cordierite-buchites with embedded microlites of tridymite, enstatite (?) and iron ore. The iron ore consists largely of magnetite crystals which occur in definite patterns. Several relict grains of quartz and few patches of reddish brown glass are also found. Fragments of semifused or baked shale and sandstone are found embedded in the fused mass. A consideration of the petrographical characters leads to the conclusion that these rocks have been formed at temperatures somewhere between 1250°C. and 1425°C.

28. Cherts from Dodguni, Tumkur district, Mysore State.

C. S. PICHAMUTHU, Mysore.

This paper reports the occurrence of cherts near Dodguni in the Tumkur district which differ markedly from any which have so far been described from Mysore State. A detailed megascopic and microscopic description of these cherts is given.

A very interesting feature of these rocks is the occurrence in them of peculiar structures which resemble algae. These are reddish brown in colour and so are clearly set off against the almost colourless silica deposit.

Hand specimens, microsections, and micro-photographs will be exhibited in illustration of the paper.

29. Sedimentary analysis of limestones from the Mysore State.

P. R. J. NAIDU *and* B. SADASIVARAJU, Bangalore.

Representative limestones from several formations of the State are examined by the methods of 'Sedimentary petrography'. The limestones occurring near the southern extension of the schist belt near Kondli, Tumkur district, show evidences of derivation from ultrabasic rocks. There are relics of tremolite which are blastoporphyritic and lie nematoblastically in a groundmass consisting of a mosaic of calcite, and pleochroic green chlorite giving a lepidoblastic structure. Biotite occurs diablastically. The amphibole gives $\alpha = 1{\cdot}535$ and $\beta = 1{\cdot}555$; the refractive indices are too low for fresh amphiboles, and represent talcose alterations.

30. Development of amphibolite near dolerite-shale contact.

M. R. SRINIVASA RAO, Bangalore.

The doleritic sill which intrudes between the Gulcherro and Vempally beds of the lower Cuddapahs near Kurnool town has metamorphosed the adjoining shales and quartzites. Field observations reveal the existence of a series of rocks, from the most unaltered shale at one end, to an amphibolite very near the doleritic intrusion. A detailed microscopic investigation of this series of rocks shows the different stages in the formation of the amphibolite as an hybrid rock due to the intimate interaction of shale and dolerite.

31. Petrology of the basic and ultrabasic rocks found near Gorumahisani Pahar, Mayurbhanj State, Orissa.

S. C. CHATTERJEE, Ranchi.

The petrographical characters and the differentiation of a series of basic and ultrabasic rocks found near the Gorumahisani Pahar are discussed in this paper. The rocks include types like norite, anorthosite, picrite, and peridotite which have a pyroxene of the Bushveld type, not previously recorded from any Indian rock, as one of the constituents. The genesis of the associated magnetite deposits has also been discussed and a metasomatic origin suggested.

General

32. The Ceylon waterfalls and their bearing on the structure of the island.

D. N. WADIA, Colombo.

The central Ceylon highland, composed entirely of Archaean rocks, is surrounded by a ring of waterfalls, which precipitate their waters over a height of from 100 feet to over 900 feet. This is a highly significant fact in the structural geology of Ceylon and indicates that the river-systems of the country have received a sudden interruption by earth disturbances which have uplifted the central highland *massif* to the extent of over a thousand feet within recent geological times. The occurrence of so many steep falls and cascades in Ceylon bespeaks sub-recent rejuvenation of the streams by block-faulting and uplift of over 1,000 feet. This has raised their waters relatively to the rest of the island and the uplift was so late that the rivers have had no time to adjust their gradients by cutting through the precipices and replacing them by gorges.

33. Some observations on the tectonics of the Sirmoor Himalayas.

K. P. RODE, Waltair.

During the recent investigations into the mineral resources of the Sirmoor State, Simla Hills, the author in the company of Messrs. Mukti Nath, R. V. J. Achyuta Rao and others of the Benares Hindu University made extensive tours in the different parts of the State. Many new facts have come to the notice which throw much light on the structure of these Himalayas. The author discusses the older interpretations of the tectonics and also puts forward some new interpretations which reveal the complicated structure of these much-studied hills.

Some of the more striking points in the new interpretation are:—

(1) Many of the conglomerates mapped as Blaini bed and as such regarded as of basic stratigraphical importance in elucidating the structure and age relationships of the outer Himalayan beds, are not strictly of normal sedimentary origin, but are in all likelihood of tectonic origin.

(2) There is a wide development of the Simlas, Infra-Krols and Krols in their normal facies in the region north of Chandpur in the north-east Sirmoor which are in contact with, and are underlain by, highly fossiliferous Nummulitic Limestone. This Nummulitic Zone extensively developed on west and north-west of Chakrata, represents a 'window' exposing and exhibiting the Autochthonous Zone of the Lower Tertiaries.

(3) The so-called Mandhalies of the eastern Sirmoor which are dominantly composed of arenacious pink, dark and buff coloured slates, shales and limestones (Bansa Limestone of Auden) appear only as hardened facies of the Simlas, Infra-Krols and Krols succession of the lowest Krol Nappe resting over the Autochthonous Nummulitic Zone.

(4) The Jaunsars of the Chandpur Stage according to Auden include the altogether unmetamorphosed greenish shales and the overlying hard quartzites forming the cliff of the Chandpur hill. These are not one continuous formation; moreover, there is also a good development of buff coloured limestone associated with the greenish shales. These limestones and shales belong definitely to the Krol zone while the overlying quartzites

highly traversed by quartz veins belong to the Jaunsars proper, the junction between the two being that of an enormous thrust, the Jaunsar Nappe lying over the Krol Nappe.

(5) Many of the so-called Chail series of shales, slates and phyllites are only metamorphosed equivalents of the Infra-Krol shales and slates and belong to the higher—the Jaunsar Nappe.

(6) The so-called Lower Tals of the Koti Dhaman and Bohal-Bitherkui regions of the eastern Sirmoor appear only as inverted sequence of the Infra-Krols and Simla slates underlying the Jutog Nappe.

(7) The so-called Upper Tals of the same regions are in the nature of Klippen and represent the remnants of the Bouleagunj Quartzites of the Jutog Nappe lying over the Jaunsar Nappe.

34. Gravity measurements in India.

P. EVANS, London *and* E. T. VACHELL, Digboi.

Large parts of India are covered by alluvial deposits which form an effective blanket concealing the geological structure and ordinary methods of geological investigation are not applicable. Various geophysical methods can be employed in such areas, and the oldest and most widely used is the determination of small variations in gravity; these variations may be expected to give some evidence of the distribution of light and dense material beneath the alluvium. The earlier gravity surveys were all made by pendulum observations, and pendulum readings have been made by the Geodetic Branch of the Survey of India at over 500 stations. For detailed work more portable and more sensitive instruments are needed and the torsion balance has been extensively used to measure gravity indirectly by determining the direction and extent of changes in gravity. This instrument has a somewhat limited application as observation stations must be closely spaced, and a number of gravimeters have been devised for a direct measurement of gravity. Three of these have been used in India during recent years; they employ different principles and are suitable for different types of operation. These three gravimeters are described with the aid of diagrams and photographs and reference is made to the accuracy obtainable and the methods of carrying out the survey.

35. Some gravity problems of eastern India.

P. EVANS, London *and* E. T. VACHELL, Digboi.

Observations of gravity (g) have been made at many places in India, and a detailed study of the many instances of anomalous gravity is possible only if the observed values can be compared with an accurate estimate of the normal gravity at the point of observation. The determination of normal gravity presents some difficulties. Firstly, the appropriate normal or calculated value (known as gamma) has to be corrected to allow for height above sea-level; this gives gamma A: then for the effects of the topographical masses and irregularities round the station; this gives gamma B. The difference between g and gamma B is the B anomaly which is the starting point for further investigation. The topographical corrections may be from one to several hundred milligals ($g = 978$ gals and 1 gal $= 1{,}000$ milligals) and the B anomaly has much the same range although it is commonly between $+20$ and -80 mgl. Obviously, the corrections must be accurate if the figure for the anomaly is to be reliable. Unfortunately, very little attention has been paid to a source of error pointed out by Glennie in India and Chamberlin in the U.S.A.: none of the calculations have taken into account the effects of local geology. The value of the anomaly is influenced by the density of the rocks near the point of observation. Corrections for density may amount to as much as 80 mgl. and may either increase or decrease the anomaly, and in some cases will change its sign. The gravity map after correcting for local geology may present a very different picture from the map of uncorrected anomalies. Two examples are given of residual anomalies after correcting for local geology—in the Bengal Delta gravity is 50 milligals more on the east than on the west, and southwards from the Mikir Hills (Assam) there is an increase of 120 milligals in 70 miles. Until more work is done on the corrections for local geology it is hardly likely that an explanation of these residual anomalies will be possible. In each of these instances the smaller gravity value lies on metamorphic rocks and the larger on comparatively light Tertiary sediments.

Economic

36. Permanganate oxidation of some Indian coals (2).

B. B. Niyogi, Dhanbad.

The present paper is a preliminary study of the relationship between the permanganate reactivity and the products of distillation of some Indian coals at high temperature. Measurements of the permanganate reactivity of the same coals were recorded by the author in a previous paper (*Fuel*, XVII, No. 8, page 228).

The results show that the observed gradual decrease in the yield of oxides of carbon and increase in the hydrogen yield in the distilled gas correspond in general with the permanganate reactivity of the different samples. The differences in cases of the Tertiary and Gondwana coals are more significant and are in accordance with what was expected. There is also a similar difference between the Barakar series and Raniganj series coals although the difference is not so marked. The temperatures of the first appearance of oil vapours also show a gradual rise corresponding to the permanganate reactivity. There is, however, no similar relationship found in case of the amount of hydrocarbons evolved.

Although these results are interesting and suggest possibilities in connection with the classification, correlation of this description can be established only by carrying out extensive work on a larger number of samples of each coal.

37. Free sulphur in some weathered Tertiary coal specimens of India.

N. N. Chatterjee, Calcutta.

In previous communications to the Geology Section of the Indian Science Congress the author gave detailed information regarding the distribution of various forms of sulphur in many Tertiary coals of India and Burma. It may be recalled that pyrites and organic sulphur were found to be present in the specimens but that in none of them free sulphur was detected by the author. A description of the specimens together with the analytical results was also published in the Journal of the Dept. of Science, Calcutta University and in the Quarterly Journal of the Geological, Mining and Metallurgical Society of India. These coal specimens were allowed to remain in the laboratory for a number of years and certain interesting changes have been noticed in them. In the present paper the author has made an attempt to give a brief account of such changes in the specimens of Borjan, Cherrapunji, Laitringow, Thanginat, Makerwal, Mach, Dandot and Jammu coals. A careful examination of the specimens shows that the organic sulphur suffered no change but the pyrite granules have been altered to sulphates with the development of sulphuric acid. In several specimens, however, granules of free sulphur were formed due to some chemical reactions between the ferric sulphate and the residual pyrites or the coal substance. Further reactions between the free sulphur and moist ferric sulphate resulted in the formation of ferrous sulphate and sulphuric acid in certain cases. In the paper the author has discussed the subject in some detail.

38. Clay from Bilaspur State, Punjab.

RAJ NATH *and* BRIJESHWAR PRASAD, Benares.

In this paper field observations on the occurrence and the results of the chemical and microscopical studies of these clays are given. Laboratory and firing experiments to study the physical properties were also carried out. All these point out that these clays from village Oel can be used for the manufacture of sanitary ware, pipes and other low grade pottery where colour is no bar.

39. Economic study of the Krol white sandstone (2).

RAJ NATH *and* BRIJESHWAR PRASAD, Benares.

At the last session of the Indian Science Congress in 1940, a paper was read on 'A source of glass sand in Bilaspur State, Punjab'.

The present paper deals with additional observations on the mode of origin of the Krol white sandstone, its suitability as a glass making material, the economic aspects of its working and with other data collected as a result of further work in the field and the laboratory.

40. Galena from Bilaspur State, Punjab.

RAJ NATH *and* BRIJESHWAR PRASAD, Benares.

This paper deals with the field observations and the microscopical and chemical studies of the country rock containing galena. The country rock in which the galena occurs is white sandstone of Krol formation which has been discovered to be a useful material for the manufacture of glass. As a result of a series of dry assaying experiments, it has been found that the amount of silver present is about one ounce per long ton of the ore.

41. Porosity, permeability and average grain size of oilsands.

N. C. SEN-GUPTA *and* MG. THEIN NYUN, Khodaung (Upper Burma).

Permeabilities of twenty-three cores were obtained by a method developed in this laboratory and described elsewhere. The corresponding porosities were obtained by the method of Melcher and the particle size distribution curves by Puri's siltometer. The average particle diameters, $\bar{d}$, were calculated from the relation $\bar{d} = \left(\frac{100}{\Sigma P_s/d_s^3}\right)^{\frac{1}{3}}$ where P_s is the percentage by volume of particles having diameter d_s. It was observed that with increase in the average diameter the porosity at first increased and then tended to attain a constant limiting value. Permeability, on the other hand, increased continuously with the average diameter and the approximate relation $K \propto \bar{d}^2$, where K is the measured permeability, was obtained.

SECTION OF GEOGRAPHY AND GEODESY

President :—GEORGE KURIYAN, B.A., B.SC. (LOND.)

1. Settlements in the irrigated areas of recent colonization in the Indo-Gangetic plain.

DR. KAZI S. AHMAD, Aligarh.

The main irrigated areas of the Indo-Gangetic plain are found in a great crescent of land extending from Karachi, through Sind, Punjab and western U.P. to about Allahabad. Within this crescent the extension of canal irrigation in the Sutlej-Jhelum doabs in the Punjab has been followed by the colonization of large tracts and, to a much smaller extent, the opening of the Sukkur Barrage has made available for colonization lands which formerly lay waste. No settlement has taken place in western U.P. after the inauguration of irrigation works as the land was already inhabited and privately owned.

The form and distribution of settlements in the canal colonies of the Punjab have been dealt with in detail, bringing out the relation of physical and cultural landscape. Village types, lay-out of principal colony towns, dwelling structures and the development of communications are described. A comparison has been made of the growth of population in the colony and non-colony districts. Although in the colony districts there is a high percentage of the increase of population since 1881, large wastes having been brought under plough, it is distributed over a greater extent of cultivated area. Therefore, the density per square mile of cultivated area is still much lower than in the old irrigated districts. The increase of wealth accruing from irrigation is thus not entirely offset by an increase of population. Therefore, the canal colonies of the Punjab form the most prosperous new settlements in India.

The extension of irrigation in Sind through the famous Sukkur Barrage presents absolutely different conditions from those of the Punjab, as far as settlement or colonization is concerned. In the irrigable land there is a marked absence of large areas, hitherto uncultivated Crown wastes, which form a familiar feature of the Punjab irrigation schemes. Here the new canals are mostly to irrigate an already settled country. Out of a gross area of $7\frac{1}{2}$ million acres commanded by the Sukkur Barrage only about $1\frac{1}{2}$ million acres were unoccupied and culturable and even these vacant lands were very fragmental. Besides, the grants of land in the Punjab under prescribed conditions are replaced here by the disposal of the bulk of the land through auction sales to meet part of the expenditure of the Barrage. So no regular plan of settlement could be enforced beyond the occupation and cultivation of fixed sites.

2. House types and settlement forms in the south-eastern Punjab.

SAIYID MUZAFER ALI, Aligarh.

This paper deals with the nature, evolution and distribution of rural and urban settlements in a region with an ancient rural economy where the tilling of the soil has, from remote times, been the mainstay of the people. The physical background of the region is first discussed bringing out the influence of natural factors on rural habitat. A number of house types, working from the nomad's tent through the hut of the semi-nomad to the house of the sedentary people, have been recognized. The manner in which these houses are grouped reveals, on careful examination, a definite pattern which is repeated in specialized regions. It is contended that the form and location of settlements are the products of at least four different factors:—

(*a*) The physical factor: soils, water distribution and weather aspects;
(*b*) The ethnic factor;
(*c*) The agricultural factor; and
(*d*) The historical factor.

3. The evolution of field pattern in Northern India.

SAIYID MUZAFER ALI, Aligarh.

An Aryan village—the 'grama', the belt of arable land, the belt of pasture land and the 'Aryana'—the effect of the increase of population on the original layout of the village—changes in the field pattern during the Hindu and Muslim periods—changes due to the different systems of land tenure—effect of political upheavals on rural economy and field pattern—settled agriculture and field patterns—relation between field patterns and religious and social customs—soil and water-supply—canals—consolidation of holdings.

4. Geography of the cotton zone of Bombay Karnatak.

C. D. DESHPANDE, Dharwar.

Economic prosperity of Bombay Karnatak depends to a great extent on cotton, its leading cash crop. The plateau tract of the region with its black and red soils and moderate but well-distributed rainfall, forms the cotton zone of Bombay Karnatak. Here cotton has promoted handicrafts and commerce ever since the antiquity. With the extension of the British rule cotton has gained a new importance. Improved varieties have promoted the export of cotton and the growth of mill industry, and have also supported the ancient handloom weaving industry. Although cotton prosperity depends on fluctuations in the world cotton prices, improvements in quality and system of marketing and development of cottage and mill industry would to a great extent stabilize economic conditions in Bombay Karnatak.

5. Geographical factors influencing the conduct of Maratha campaigns in Bombay Karnatak.

C. D. DESHPANDE, Dharwar.

Rajwade, the well-known historian of the Marathas, in his Prefaces to Maratha Sources, points out the importance of the season of campaigns, and the routes followed by the Maratha armies. A detailed study of such routes with reference to a small region like Bombay Karnatak brings out the local influences of geographical factors such as the length of the rainy season, unseasonal rains, famines, water scarcity, hilly and forested regions and river fordings. Campaigns of Bajirao I, Madhavrao Ballal, Parshuram Bhau and Haripant Phadke have been taken as illustrations. A consideration of the relative importance of the routes of campaign in Bombay Karnatak shows that the western or the 'Krishna Valley' route, developed by the Patwardhans, became more important than the other routes in the east, and to this extent, Rajwade's description of routes requires a revaluation.

6. Settlement types of Bombay Karnatak.

C. D. DESHPANDE, Dharwar.

Urban and rural settlements of Bombay Karnatak conform to the general pattern as determined by geographical influences although there are local variations. Influence of relief, soil and fresh water supply, modified in places by roads, determines the site and pattern of villages, while the amount of rainfall and the nature of building material available influence the plan and construction of house types. Superior position of fertile land and nature of agricultural operations—factors of human geography—also exercise some influence in the pattern. The size of settlements is open to a variety of influences. Weekly bazars, major roads, river fordings, riverside situation in places supported by religious sentiment and prosperous agricultural surroundings are factors promoting their size, while malarial conditions, animal pests, absence of economic support from agriculture exercise a negative influence. The scattered settlements of Kanara coast, the straggling hamlets of the Ghats, the prosperous villages of the transitional and black soil regions and the poorer village types of the eastern side have been discussed in this setting, on a regional basis, along with a reference to urban types.

7. Eustatic changes in level in the south-east coast of Madras.

V. KALYANASUNDARAM, Madras.

The paper deals with the changes in the relative level of the land and sea in the south-east coast of Madras. The geological evidences, as far as they have been worked out, point to an elevation of the coast within recent times and historical records indicate a continuance of this process—the recession of the sea—down to historic times also. The longitudinal profile of the main river of the region, the Tambraparni, reveals a succession of breaks of slope and it is particularly suggestive when this feature is developed, as in the case of the region under consideration, in massive crystalline rocks. They reveal the former high levels of erosion, a fact which is in keeping with the purely geological evidence.

8. Hydro-electric development in South India.

V. P. KANNAN NAIR, Madras.

The paper describes and discusses the place of water power in South India; what it has done and can do for the industrial regeneration of a region utterly deficient in coal and oil. It shows how the water power developments that have recently taken place in the region are in strict accord with geographical factors. Nothing is so vital to the material progress of South India as the development of all her remaining water power resources which, as in Japan, can reasonably be expected to solve all the problems of power, arising directly from the absence of coal and oil.

9. Agricultural regions of Bihar.

S. A. MAJID, Patna.

This paper represents an attempt to divide the province into a number of agricultural regions based mainly on the crops. The relation between the geographical factors and the distribution of the main crops has been fully discussed. The coincidence of the boundary lines of most of the regions with the contours and isohyets has been sought out and presented. The relative importance of the different crops raised in a region has been carefully determined and the factors leading to it critically analyzed. The main facts emerging from the discussions have been illustrated by a number of maps of the writer's own making.

10. Coconut—its cultivation on the Malabar coast.

P. KOCHUNNI PANIKKAR, Madras.

The cultivation of coconut and the industrial utilization of its many parts are long-established occupations of the people of Kerala.

The coconut-producing regions of the world are the islands and mainlands lying in the tropics. The areas of concentration are the tropical lands of the Indian and the Pacific Oceans. India contributes 19% of the world production and ranks second to the Philippines only in the extent of coconut cultivation. The Malabar coast constitutes the area of major concentration, with more than 70% of the Indian acreage.

The geographic factors responsible for this large share of the Malabar coast are its climate, soil, physical features (not the least important of which is the labyrinth of canals, backwaters and streams) and the availability of adequate and cheap manual labour and an assured home market.

In Kerala the cultivation of coconut is not done on a plantation scale as in the Philippines and Ceylon.

In this paper an attempt is made to examine in detail the density of coconut culture in the several taluks and an explanation is offered for the varying degrees of importance. Statistics of employment show that the cultivation of coconut and its associated industries rank second only to the cultivation of rice among the occupations of the people of Kerala. The advantage of coconut culture and coconut industries over other industries—except the cultivation of rice—lies mainly in the facilities that Kerala offers for the economic utilization of every part of the plant. Coconut is practically the only cash crop available all through the year and hence the preference shown to it.

11. Geographical science as an aid to the unification of Indian cultures.

MANECK B. PITHAWALLA, Karachi.

In the present paper an attempt has been made to point out the importance of geography as an aid to the unification of India's varied cultures, resulting in an all-India civilization. Historians are keen on finding the essential unity of our country; but without establishing the cultural boundaries forming natural regions, in place of the unnatural political or provincial boundaries, it will be impossible to achieve this object. There must be a suitable interchange of the material and moral wealth of every one of them. The clash of cultures and the miseries of disharmony accruing therefrom are due to want of understanding of the characteristics and achievements of the communities and classes of people, living in the same land but influenced by the numerous physiographic regions. To interpret the complex relationship between man and Nature in all of them, the cultural science of geography—the sum-total of all sciences—should be studied. A historical geography of India, properly produced, should be very helpful in solving many of India's present problems. Geography should, therefore, be an essential part of our University syllabuses and provision must be made for research work in the Arts as well as the Science Faculties.

Indian cultures are like oases in the vast desert of human barbarism. It is our task to unify these by a process of irrigation, causing a happy mingling of their spiritual waters in order to create a united, strong and peaceful nation, without losing the individuality of each.

To establish the thesis, the example has been given of the Indus valley, particularly the lower Indus valley (Sind) lying in the Afrasian belt of civilization, as a definite physiographic region, which has produced a unique culture under unique geographical conditions, briefly enumerated in the paper.

12. The life of Tanjore ryots.

M. P. RAJAGOPAL, Madras.

The paper examines in detail the annual rhythm in paddy cultivation in Tanjore district which is purely a rice-growing region. It points out that the yield of paddy has been declining of late, in this region, partly because of soil exhaustion, and partly also because of the adverse effect of the Mettur Dam. Suggestions are given to improve the agriculture by the cultivation of some alternative crops both to enrich the exhausted soil and to engage the ryots during the period of his inactivity. The imperative need for the development of some possible cottage industries, on account of the inadequacy of agricultural resources in the region, is being stressed.

13. The agricultural regions of Mysore.

H. RAJARAMA RAO, Bangalore.

The paper deals with the 'Agricultural Regions of Mysore' taking into consideration the several factors that distinguish the different crop zones and their distribution. The geographical aspect is first dealt with, analyzing the physical factors, such as, climate and soil influencing crop production in Mysore State. These physical factors are also found to be the basis for the classification into natural regions. The distribution of the crops with reference to their conditions of growth, facilities for their cultivation, the nature of the crop types and the physical factors responsible for their growth are dealt with in some detail. Finally, the striking correlation between the crop associations and the natural regions is discussed at some length.

14. Mango showers and agricultural operations of Tamil Nad.

K. RAMAMURTHY, Madras.

Before the onset of the regular monsoon in June, July and August there are certain convection showers accompanied with hail and thunder, offering a break to the regime of heat, increasing from March. These have been turned to advantage by the ryots who begin ploughing; and prepare the soil for dry crops; or plough the land and lay it fallow for better aeration. In northern Tamil Nad, they advance and anticipate agricultural operations under the south-west monsoon; or raise dry crops such as Gingelly oil-seeds, which thrive best under such showers. Small as is the scale of these agricultural operations, they have a special place in the ryot's economy. These done, the April-May months are generally agricultural holidays and the ryots enjoy themselves in marriage festivities, feasts and festivals.

15. Seasonal control of rural life and activities in the Conjeeveram region.

N. SUBRAHMANYAM, Madras.

The paper discusses and brings out the control of the cycle of the seasons over rural activities, as illustrated in the Conjeeveram region of South India. After giving a brief account of the surface, soil, temperature and rainfall conditions of the area, the regime of the Palar and the types of irrigation in the region are described as also the characteristics of the several seasons therein. The human activities in the rural parts of the region are then discussed fully in relation to each of the seasons, bringing out the control in each case. Finally, the seasonal control of human activities in this region is contrasted with conditions in (1) England, (2) North-Western India, and (3) west coast region of South India.

16. Localization of crops in India.

N. Sundararama Sastry, Madras.

In this paper an attempt is made to study the geographical distributions of crops in India (excluding Burma) in the period 1920–35. According to the Agricultural Statistics of India, the crops are divided into two groups, namely, food and non-food. The food crops are again subdivided into (1) food grains, (2) condiments, (3) sugar, (4) fruits and vegetables, and (5) miscellaneous. The non-food crops are subdivided into (1) oil-seeds, (2) fibres, (3) dyes and tanning materials, (4) drugs and narcotics, (5) fodder crops, and (6) miscellaneous. The percentage area under each group and sub-group in the main provinces—(1) Bengal, (2) Bihar and Orissa, (3) Bombay, (4) Central Provinces, (5) Madras, (6) Punjab, and (7) United Provinces—is calculated for each of the three quinquenniums, and this is compared with the share of each in the whole of India. Again, the distribution of crops is compared with the distribution of population in the different regions. Finally, an attempt is made to explain the distribution from geographical factors.

SECTION OF BOTANY

President:—N. L. Bor, M.A., D.Sc., F.L.S., F.N.I., I.F.S.

Ecology

1. On some ecological features of the flora of Mt. Abu.

T. S. Mahabale *and* R. G. Kharadi, Ahmedabad.

The paper gives an account of some ecological features of the flora of Mt. Abu and describes the various factors affecting its vegetation. Different types of vegetation commonly found at different altitudes of the mountain are systematically treated and an account of their principal associations is given. It has been shown that this flora is very rich in point of its component elements and their formations. The most important formation at Mt. Abu is *Euphorbia-Anogeissus-Celastrus* formation, and it seems to represent the edaphic climax. It owes its origin to topographical succession. This formation contains, *inter alia,* a large proportion of *Phoenix sylvestris* trees even above 5,000 feet elevation, and this is rather surprising. In the valleys a rich flora of the monsoon deciduous type containing *Eugenia Jambolana, Dalbergia Sisoo, Odina Wodier* prevails.

In general, the flora of Mt. Abu seems to conform to the flora of the Upper monsoon deciduous forests found on the outer slopes of the Himalayas. Judging from the distribution of the various formations seen round the mountain at present, one is led to believe that it must have been an important radiating centre for the distribution of species for a very long time.

2. A preliminary survey of the flora of Pavagadh (eastern Gujarat).

V. L. Devkar, Baroda.

The geological survey of the south-west of the district of Panch Mahals shows the great trap rock of Pavagadh, the chief natural feature and one of the places of greatest interest in eastern Gujarat. From time to time people have visited this historical place of interest, yet an attempt to put on record the interesting flora of this beautiful spot has never been made. The author has, therefore, given in the text of the paper an account of the vegetation of Pavagadh based on a few trips made at different times. Pavagadh is about 26 miles round and rises about 2,500 ft. above the plain. It is 29 miles east of Baroda and its average rainfall is about 65 inches.

Some of the most interesting plants described are as follows:—

Angiosperms—

Anona squamosa Linn.
Bombax malabaricum DC.
Boswellia serrata Roxb.
Azadirachta indica A. Juss.
Desmodium sp.
Butea frondosa Roxb.
Acacia catechu Willd.
Terminalia belerica Roxb.

Diospyros montana Roxb.
Tectona grandis Linn.
Santalum album Linn.
Fluggea leucopyrus Willd.

Pteridophytes—

Ferns—*Epiphytic and terrestrial.*

Microlepia strigosa Moor.
Adiantum lunulatum Burm.
Cheilanthes farinosa Kaulf.
Pteris sp.
Athyrium hohonackerianum Bedd.
Athyrium felix faemina Roth.
Nephrodium molle Desv.
Pleopeltis linearis Bedd.
Pleopeltis membranacea Bedd.
Pleopeltis punctata Bedd.
Gymnopteris quercifolia Bernh.

Bryphytes—*Epiphytic and terrestrial.*

Hepaticae—

Riccia sps. (2).
Cyathodium sp.
Conocephalus sp.
Fimbriaria sp.

Musci—

Tortula squarrosa.
Hypnum sps. (2).
Funaria sp.
Micropoma sp.

3. A note on the phenology of the phanerogams of Travancore.

N. K. B. Kurupp, Travancore.

The paper deals with the phenomenon of periodicity in the sexual domain of the phanerogams of Travancore. In Rama Rao's 'Flowering plants of Travancore', he makes specific mention about the flowering time of 1,271 species. Forest trees of Travancore written by Bourdillon gives us information regarding the flowering time of 512 woody plants. From a study of the facts gathered from the above two works, it is seen that Schimper's conception that the favourable influence of the dry seasons on the development of flowers could be most clearly recognized.

4. Algal succession on a rocky island, Charaiguha, in the Chilka Lake.

P. Parija *and* B. Parija, Cuttack.

This small island is bare and rocky and is situated in the Chilka Lake near Balugaon. It receives its local name from the abundance of droppings of birds which rest on it. The contour is elliptical; the major axis measures 125′ and the minor 64′. The rock is traversed by wide cracks and crevices and is bathed by lake water up to various heights in different seasons.

Observations on the change of level salinity, *p*H and penetrability of light in the lake water have been recorded.

Consequent on these and the change of season, there is an algal succession in the island which is recorded here.

An attempt is made to correlate this succession with external factors.

Floristic

5. A study of some of the grasses of H.E.H. the Nizam's Dominions, Hyderabad-Deccan.

M. Sayeedud-Din *and* M. R. Suxena, Hyderabad-Deccan.

An account is given of 49 genera and 79 species of grasses of Hyderabad. Most of the material for this paper has been collected from the Telangana region where the soil mainly consists of laterite and '*Murum*'. Judging from the reports of the Bombay grasses and those of the Madras Presidency one may expect to find at least 360 species of grasses in Hyderabad.

Physiology

6. Studies on the autonomic movements of leaf in *Mimosa pudica* and *Desmodium gyrans*.

C. V. Krishna Iyengar, Mysore.

Desmodium gyrans and *Mimosa pudica* are the plants selected for this paper although the leaf movements in many other plants have also been studied. The observations indicate that autonomic movement is seen not only in *Desmodium gyrans* but also in *Mimosa pudica* and many other members with pulvinate and non-pulvinate leaves. It is however noticed that most interesting variations in the rate of movement are manifested by members where the petiole is least woody. The observations also point out that the blade has no rôle in the petiolar movement but on the other hand might come in the way of its magnitude by its weight, thus doing away with the possible rôle of photosynthesis of the blade in the movement. The movement (with its fluctuations in rate and magnitude) is observed whether the plant is in bright or diffuse light, natural or artificial. In a typical member like *Desmodium gyrans* the leaf exhibits two kinds of movements, the petiolar and the leaflet movement (resulting in the primary and secondary curves of the graphs) the magnitude of the former directly or indirectly influencing the latter. In all my observations I have noticed that the time of the day has its effect on the rate and magnitude of the petiolar movement and that a higher rate or magnitude is often followed by a lower one. There is a visible fall in these (roughly between 12-30 and 2 P.M.) when transpiration is generally at its best, resulting in the poor water-content of the plant body. Thus the movement of the petiole depends directly on the variation in the turgidity of the leaf-base and indirectly on that of the plant body. The movement of the petiole may be taken as an indication of the periodic fluctuations in the water-content of the plant due to various activities.

7. Physiological studies of mangoes (*Mangifera indica* Linn., variety—Fazli) during development on the tree and in storage.

S. M. Sircar, Calcutta.

The paper presents the results of a preliminary study on the morphological and physiological changes of mangoes, variety Fazli, during development on the tree and in storage. Nine weekly samples were collected from Malda, Bengal. As the fruits matured on the tree the following morphological character were noted: (1) nature of shoulders, (2) colour of skin and pulp, (3) texture of skin and pulp, (4) nature of endocarp (stone), and (5) taste and flavour of pulp.

The following chemical constituents of the pulp were analyzed: reducing sugar, sucrose, total sugar, titrable acid, *p*H and alcohol insoluble and soluble materials. With the development of the fruit reducing sugar is regularly falling in concentration while sucrose and total sugar are accumulating. Acidity as determined by titration and pH measurements is diminishing in the successive picks. Important changes are noticed at the period of stone formation. Sugar variations in the pulp before and after stone formation suggest that a considerable amount of reducing sugar is being utilized for the development of stone. Morphological and physiological changes of mangoes in short-period storage have been studied and the following observations are recorded. During storage the acidity steadily falls and the concentration of reducing sugar is diminished and starch gradually disappears while sucrose accumulates. Rotting generally takes place when acidity falls to a very low value and pH approaches or even passes the neutral point.

8. Effect of phosphorus and potassium deficiency on growth and absorption of salts in wheat.

S. M. Sircar *and* Asutosh Das, Calcutta.

A sand culture experiment is described in which wheat, variety Pusa 52, was grown in three series of nutrients: (i) complete nutrient (F.M.), (ii) 0·33 level of potassium (—K), and (iii) 0·037 level of phosphorus (—P). After sixth week phosphorus deficiency series was compensated (—P+P). Growth in length, number of tillering and ear emergence were recorded. At the beginning of the second week there was no difference in height between F.M. and —K series but —P series showed an appreciable difference. In F.M. series plant-heights were always greater than —K and —P. The height differences between F.M. and —P were very great. There was no difference in tillering between F.M. and —K up to fifth week. A marked difference was noticed in the later period. —K plants showed more tillers than F.M. plants. —P plants always had a very small number of tillers. Addition of P showed an improved tillering. As each leaf reached maturity determinations of total nitrogen and phosphorus were made. At harvest estimations of nitrogen and phosphorus were made of ear, root and straw. There was a fall in nitrogen content in the successive leaves of each series of the plants, but phosphorus concentration remained almost constant. The uptake of nitrogen was found to depend on phosphorus concentration; it increased with the addition of phosphorus. Nitrogen uptake did not depend on potassium concentration but phosphorus absorption was dependent on potassium.

9. Further studies on photoperiodic response in rice.

S. M. Sircar *and* Pyarimohan Samantaray, Calcutta.

A preliminary study was made in the last year to determine the relationship between the length of exposure to light and plant growth on one hand and earliness in reproduction on the other in one variety of winter paddy (Var. Bhasamanik). The length of exposure to light was 8 hours sunlight, and for the rest of the day the plants were kept in the dark. The reduction in day length had no adverse effect on vegetative growth and grain yield; on the contrary an increase in the yield was noticed. As compared with the control plants (full daylight) an earliness in flowering of approximately 20 days was noticed in plants receiving 8 hours sunlight.

With this knowledge of the photoperiodic effect in this variety an experiment is being carried out to determine its full economic value. The developmental phase at which a plant responds to photoperiodic treatment determines the practical application of the process. An attempt to induce rice plants to pass the light stage before transplantation will be of great economic importance. Accordingly, light treatments of different day lengths (6, 8 and 10 hours) were given to rice seedlings in the seed bed. The treatment was begun when the seedlings were 7 days old and continued for 2, 3, 4, 5 and 6 weeks in different sets, and the seedlings were subsequently transplanted in pots. Growth behaviour of different sets of plants is found to be normal. Photographs will be presented to show the effect of different light periods on the date of ear emergence and the maturation of ears.

10. Presence of sodium in plants in the neighbourhood of Calcutta.

J. C. SEN-GUPTA, Calcutta.

In a previous paper the author (1939) tested the suitability of the method suggested by Steiner (1935) as an improvement to the previously known methods for the histo-chemical test for sodium and confirmed this in general; and investigated the presence of sodium in some common plants near Calcutta.

The river Hooghly and the different canals passing through the Calcutta Salt Lakes in the west of the town carry saline water, at least during some time of the year.

In the present paper the author has tested some samples of water, soil and plants from the surroundings of Calcutta, including areas in the Royal Botanic Gardens and some parts of the Salt Lake area near Chingreehatta.

In some cases where the same areas were investigated in May and August there was a distinct difference.

The author is engaged in studying the annual variation for some definite selected localities. The details are given in the paper.

11. Hydrocyanic acid in the maize plant (*Zea mays*).

K. N. BAGCHI *and* H. D. GANGULY, Calcutta.

In a previous communication (Bagchi and Ganguly, *Proc. Ind. Sci. Cong.*, 1940) it has been shown that HCN is present in sorghum (*Sorghum vulgare*) in varying quantities at different stages of its growth. As maize and sorghum plants look exactly alike when they are young, this investigation was taken up to see if HCN could be detected in the maize plant as well.

For purposes of our investigation the plants were grown in the garden attached to the laboratory so that they could be analyzed at frequent intervals and at every stage of their growth. The following is the result of analyses of different parts of the plant (figures indicating per cent of HCN).

	Roots.	Stems.	Leaves.	Seeds and flowers.
Plants 1 to 3 inches in height	0·035	0·015	0·018	..
Plants 16 to 20 inches in height	0·0078	0·0052	0·0065	..
Mature plant at its full height	0·0052	0·0026	0·0039	..
Flowering plants ..	Nil	Nil	Nil	Nil

Hydrocyanic acid is present in the plant not as a free acid nor as a simple compound with an organic or inorganic base but as a cyanogenetic glucoside which is hydrolyzed into glucose, HCN and other components known as aglucones, if soaked in water or in very dilute acids or alkalis for 2–4 hours before distillation. Stronger acids and alkalis (N/10 for example) retard the action and no HCN is obtained. The hydrolysis of glucoside is brought about by an enzyme which is present along with it in the particular organ of the plant where the glucoside is retained.

12. Significance of hydrocyanic acid in plant nutrition.

K. N. Bagchi *and* H. D. Ganguly, Calcutta.

Hydrocyanic acid is present as cyanogenetic glucosides in a large number of plants. It is present as a mere trace in every part of the plant but its maximum concentration is found in certain organs which are not the same in all kinds of plants. For instance, in linseed the maximum amount of hydrocyanic acid is in the fertilized flowers (Bagchi and Ganguly, *Ind. Jour. Vet. Sci. & Anim. Husb.*, 1939) and not in the roots, leaves or seeds; in maize and sorghum grass (*Sorghum vulgare*) it is in the sprouts (plumules and radicles) at the earliest stage of their growth and in the roots when they are mature; it is in the leaves in cherry laurel (*Prunus laurocerasus*), and in the seeds in bitter almonds and pakra (*Schleichera trijuga*).

By growing *Sorghum vulgare* in the laboratory it has been observed that when the seeds germinate and the sprouts are about an inch in length they contain the maximum amount (0·46%) of HCN, while the seeds do not contain any. As it grows larger and larger, the concentration of HCN in the roots and stems become progressively less and finally it drops down to 0·018% in the roots and a trace (below 0·004%) in the stems and leaves. Similarly, in linseed plant the HCN-content of flowers (just after fertilization) is about 0·69%, while in roots, stems and seeds it does not usually exceed 0·06%.

From the facts stated above the following problems may present themselves for solution:—

(1) Do the cyanogenetic glucosides possess special affinity for certain tissues or organs where they perform specific physiological functions for purposes of nutrition or fertilization?

(2) Is the synthesis of these glucosides carried out all over the plant body or confined to certain organs only?

(3) Is there any difference in the histological structures of tissues which synthesize or retain these glucosides?

(4) Are these glucosides produced primarily for some specific purpose or converted as such from glucose, HCN and other aglucones as the result of an attempt on the part of the plant to render innocuous the poisonous dose of HCN formed during metabolic activities going on in certain organs?

(5) As these glucosides and their corresponding enzymes, which bring about their hydrolysis and liberate free HCN, glucose, etc., are usually found side by side, may it not be suggested that HCN is required by certain plants for their normal physiological functions and the glucosides containing HCN are stored in a convenient organ of the plant for a steady supply of HCN when required?

(6) Do the enzymes which hydrolyze glucosides and liberate free HCN possess a reversible action for resynthesis of surplus HCN, glucoses, etc., into the original glucoside?

Investigations on the above lines may give interesting results which are likely to throw a flood of light on metabolism of plant tissues.

Anatomy

13. Structure of the gynoecium in male flowers of *Osmanthus suavis* King.

A. C. Joshi, Benares.

The anatomy of the male flowers of *Osmanthus suavis* (Fam. Oleaceae) with special reference to the form and vascular structure of the gynoecium is described. The 4-lobed calyx is supplied by four midrib and four commisural collateral traces, the vascular supply of each sepal being based on the $\frac{1}{2}+1+\frac{1}{2}$ plan. Each of the four petals receives a single concentric trace, which splits above into three collateral bundles. Each stamen receives one bundle, which is concentric throughout its length. The carpels are united in the lower part to form a closed ovary, but this is unilocular unlike the ovary of the bisexual flowers. Further, in the upper part it opens out into two leaf-like carpels with free margins. This clearly shows that the gynoecium is composed of two carpels and refutes the polymorphic interpretation of Saunders. There are no ovules or their rudiments. Each carpel receives three traces, of which the dorsal one is better developed. The laterals are weak and die out in the free part of the carpels. This proves that the great development of the lateral veins in ordinary fertile angiospermous carpels is a purely physiological phenomenon connected with the nourishment of the ovules and has no morphological significance. A third carpel has been observed in one flower within the two normal carpels. It alternates in position with the outer whorl and is supplied by only one bundle. All carpel traces are collateral throughout their length.

14. Ovule and embryo-sac of *Piper longum* Linn.

A. C. Joshi, Benares.

The ovule possesses two integuments, of which the inner alone forms the micropyle. The nucellus is characterized by the development of a meristematic zone at its chalazal end. The primary archesporial cell cuts off a parietal cell. The megaspore mother-cell directly gives rise to the embryo-sac. The embryo-sac is of the tetrasporic type and four nuclear divisions intervene between the megaspore mother-cell and the formation of the complete embryo-sac. The nuclei of the embryo-sac after the second division show 1+3 arrangement. The three chalazal nuclei fuse during the third division, resulting in the formation of a new 4-nucleate embryo-sac with large chalazal nuclei and smaller micropylar nuclei. The mature embryo-sac is 7-nucleate after the fusion of polar nuclei. Thus the development of the embryo-sac in *Piper longum* follows the *Fritillaria*-type.

15. A study on pollen morphology—its importance in the identification, classification and phylogeny of the family Acanthaceae.

Satinath Bhaduri, Calcutta.

Thirty species belonging to twenty-one genera have been studied. Largest grains were observed in *Ruellia prostata* (89–105μ), *Barleria cristata var. dichotoma* (84–95μ), *Eranthemum nervosum* (89–110μ), while smallest grains in *Nelsonia campestris* (23–25μ), *Rungia parviflora* (23–25$\mu \times$ 14–17μ) and *Justicia procumbens* (24–39$\mu \times$ 16–20μ). Other species form an intermediate series. Grains of *Thunbergia*, *Crossandra* and *Acanthus* generally rupture quickly in lactic acid and water; others do not. Dimorphism in size and shape was found to be a specific character of *Hygrophila spinosa* T. And. which has three types of grains. *Rhinacanthus* *communis* Nees, *Justicia Betonica* L., *Justicia gendarussa* L., *Justicia procumbens* Nees and *Adhatoda vasica* L. show dimorphic grains of various degrees. Such dimorphism is generally due to hybridization. *Asystasia coromandeliana* Nees has bean-shaped grains and *Crossandra* has cylindrical to dumb-bell shaped grains but mostly the grains are ellipsoidal and spheroidal in the other genera of the family. Pollen colour is mostly yellow; rarely yellow-buff, white, pinkish white, greenish white and other shades of these colours are also found. Starch contents of the pollen grains do not form a very important character in the family. Only about thirty per cent of the species examined showed starch, as reserve products. In dimorphic species, the presence of starch is restricted to a particular form of pollen grain. Number of germ pores is generally three. *Ruellia prostrata* Lamk. (6), *Cardanthera triflora* Ham. (4), *Sanchezia nobilis* Hook. (2), *Rungia parviflora* Nees (2), and *Adhatoda vasica* L. (2) have germ pores other than three. Harmomegathi are peculiar structures quite characteristic of this family. Generally they are meridionally arranged, with their ends mostly attenuated. They are either free or united at the poles. *Dicliptera Roxburghiana* and *Hemigraphis hirta* have harmomegathi which are not attenuated, and in *Micranthus parviflora* Wendl. they are slightly obliquely arranged and meridional. The intine generally protrudes out of the germinal apertures in the form of papillae. *Justicia gendarussa* L., *Justicia Betonica* L., *Odontonemella indicum* Lindau and a few other species have their protruding intine adorned with granules. Exine may be smooth, variously granular or lophate. Four types of lophate grains have been distinguished. Tape-like, spiral or ring-like exines have been observed in *Thunbergia* and *Sanchezia*. Percentage of defective grains is high in cultivated species, e.g., in *Justicia gendarussa* L. (33%), *Rhinacanthus communis* Nees (15%) and *Barleria cristata* L. (above 95%).

A key to the identification of species of plants from only pollen character is given, which aims at correct identification of different genera and in some cases of species of the family.

Lindau's work has been thoroughly reviewed and irregularities of his observations have been pointed out in the light of the present investigation. The characters of *Nelsonia campestris* Br. have been found to be more allied to *Andrographis panniculata* Nees, hence its shifting to the tribe Andrographideae of the sub-family Nelsonioideae—the position assigned to it by Lindau has been proposed.

Grains of *Justicia adhatoda* L. were erroneously drawn by Lindau in 'Engler's Jahrbucher' on account of faulty observation. Hooker in 'Flora of British India' placed it in a separate genus, *Adhatoda* Nees, on a purely morphological basis. The peculiar pattern of the exine, lacunar series in the intra-colpar region and two big germ pores of *Adhatoda* are considered by the author to be characters sufficient to remove it from *Justicia* and raise to a separate genus.

Composite nature of the family, based on pollen characters, has been discussed.

A tentative phylogenetic, based only on pollen morphology, has been worked out. Phylogeny of the family has been discussed in the same line.

16. Xylem rays in relation to the eccentric rings and the spiral grain in the wood of *Pinus longifolia*, Roxb.

PARASURAM MISRA, Cuttack.

In horizontal coniferous branches, where the successive rings are eccentric but the widest regions are confined to the vertically lower side of the branch, the wood rays are found to be curving upwards, on the lateral sides of the branch. This may be explained by assuming that the rays form normals to the circumferences of the successive rings.

In the stem of the twisted chir pine, the growth rings are eccentric and the widest regions of the different rings may lie on different radii. The rays are observed to take a zigzag course, if the eccentricity changes sides very often, forming normals to the circumferences of the successive rings.

Clockwise shift of the rays appears to be correlated with the clockwise or left twist of the spiral grain, and further clockwise shift of the rays in the subsequent rings tends to increase the left or the clockwise twist and anti-clockwise shift of the rays tends to decrease the left twist.

17. Studies in floral anatomy. VI. Vascular anatomy of the flower of certain Passifloras.

V. Puri, Meerut.

The vascular ground plan of the flower of all the three species studied here is the same. Ten vascular bundles leave the stele at the base of the receptacle. Five enter the sepals and five the petals. But in *Passiflora suberosa*, an apetalous species collected from Dacca, all the bundles which are usually ten but may be less—up to five—enter the sepals. As the petal traces pass out they leave behind numerous branches for the various rings of the corona. Later on five traces are given out for the five stamens. Alternating with the staminal traces and forming an outer ring are often seen five bundles which run only for a short distance. These are probably the vascular studs of the staminodal traces which may have been possessed by the ancestral forms. The remaining vascular tissue in the stele forms a triangle in cross section and supplies traces to the carpels.

18. Studies in floral anatomy. VII. Vascular anatomy of the flower of certain Cucurbits.

V. Puri, Meerut.

It is a common experience that the stigmas in the family Cucurbitaceae are commissural, that is, they are borne above the dividing lines between the carpels, and not, as we should expect, above their dorsal sutures. Since the commissural stigmas in the Cruciferae have been interpreted differently, it is necessary to find out if the same interpretation could also be applied to the condition in the Cucurbitaceae. With this idea in view some ten Cucurbits have been sectioned on the microtome and their examination is in progress. The study promises to throw some light on the nature of the carpels and the type of placentation.

19. Origin and nature of the sclerenchyma ring in the stems of Cucurbitaceous plants.

B. C. Kundu, Calcutta.

In the adult stems of many Cucurbitaceous plants a ring of sclerenchyma fibres is usually found surrounding the vascular bundles. This ring is continuous in the majority of cases and is more or less wavy in outline. In certain cases, however, particularly in woody stems, the ring is not quite continuous, but appears as more or less isolated segments lying opposite the vascular bundles in the form of caps.

In those species where there is no appreciable secondary growth in thickness this ring remains continuous in later stages also; but in species where a vigorous secondary growth in thickness takes place, as for example in *Lagenaria vulgaris* and others, the continuous ring is broken into a number of segments.

This ring has been studied by many previous workers, who have variously designated it as pericycle, subcortical sclerenchyma, bast ring, medio-cortex or endocortex. The author has investigated the origin and nature of this fibrous ring from a developmental point of view from serial microtome sections of the growing point. He has observed that the ring at least in part is developed from the same procambial strands which develop the vascular bundles. This type of development of the sclerenchyma from the same procambial strand which also develops the vascular bundles has, so far as the author is aware, not been previously reported in any other case.

The method of development of the fibres and their nature and structure have been described in detail.

There is an intimate relationship between the sclerenchyma and the vascular bundles which can be substantiated by the further behaviour of both the bundles and the fibrous ring at the time when the leaf traces leave the central cylinder.

The term 'pericycle' which has been used in describing this fibrous ring denotes a tissue independent of vascular tissues in origin. The other terms used in this connection do not appear to me appropriate on account of its method of origin. So the writer proposes to reject the designations previously applied to this ring of fibres and suggests the name 'peristelar sclerenchyma' for it in the stems of the Cucurbitaceae. This term will not only denote their origin, but will also signify the position of this ring in the adult stem. Moreover, it appears to be useful and more appropriate for practical purposes.

The parenchyma inside the 'peristelar sclerenchyma' and surrounding the vascular bundles has been termed by previous workers as endocortex, parenchymatous pericycle, extrafascicular parenchyma and combined endodermis and pericambium. The origin of this parenchyma tissue has been studied and the designation 'extrafascicular parenchyma' as proposed by Zimmermann is in the opinion of the writer most suitable.

20. A comparative study of the structure of pollen grains in some of the families of Angiosperms.

M. SAYEEDUD-DIN, M. ABDUS SALAM, *and* M. R. SUXENA, Hyderabad-Deccan.

The structure of the pollen grains has been studied in fifty-two families of Angiosperms out of which forty-four are dicotyledons and eight monocotyledons. In the majority of plants investigated pollen colour varies from pale cream to yellow. Some, however, possess an orange, blue or brown colour. Grains are in most cases sticky, while loose grains occur in a few cases. The great majority of families possess ellipsoidal grains. Next come those families which have spherical grains. A fair number of families possess cylindrical grains, while a limited number are characterized by the possession of tetrahedral grains. Only a few possess pyramidal grains. With regard to the external markings the pollen grains may be classified as smooth, reticulate, echinate, and with pores. Size is the least constant feature. It has been found out that sometimes most highly evolved families possess very primitive type of pollen grains, and *vice versa*. Therefore it is very doubtful if a natural classification for the identification of families can be worked out in the absence of a definite rule governing the distribution of pollen grains in various families.

21. On the anatomy of some of the Urticaceae.

M. ABDUS SALAM *and* M. SAYEEDUD-DIN, Hyderabad-Deccan.

The anatomy of *Pilea microphylla* Liebm., *Pellionia Daveauana* Br., and *Holoptelea integrifolia* Planch. has been investigated. The following characters are noteworthy:

In contrast to the Moraceae, the Urticaceae are characterized by the absence of laticiferous tubes and the frequent presence of cystoliths. The stomata usually possess three subsidiary cells, for example, in *Pilea* and *Pellionia.* The hairy covering consists of simple unicellular hairs, and small glandular hairs. *Pellionia,* however, contains small peltate glands which secrete a mucilaginous substance, and *Pilea* contains secretory canals. The cystoliths are generally ellipsoidal in form, viz., in *Pilea* and *Pellionia.* Besides these clustered crystals of oxalate of lime occur in *Pellionia* and *Holoptelea.*

22. A note on the origin and nature of the starch sheath in three dicotyledonous stems.

GIRIJA PRASANNA MAJUMDAR, Calcutta.

Endodermis and starch sheath are used synonymously in most of the modern textbooks though they differ in structure, cell contents and in distribution. The origin of both has been located in the innermost layer of the cortex (*plerome sheath* of Sachs, *phlaeoterma* of Strasburger), but Eames and MacDaniels think that they are stelar in origin, being the outermost layer of the stele.

Endodermis is an uninterrupted sheath, and a pericycle always intervenes between this layer and the vascular bundles. Starch sheath, on the other hand, may be continuous (mainly in adult parts), or interrupted, and a pericycle has not been found interpolated between this layer and the vascular bundles in the species studied.

Endodermis is primarily found in roots, but in certain cases it replaces starch sheath in stem or leaf. This appears to be connected with the control that is required to be put on the lateral passage of water in the particular organ. Starch sheath has not been reported in roots.

Starch sheath originates in the species studied as *Stärke-sicheln* of leaf-trace bundles, and only at a later period the starch crescent of each trace bundle unites to form the wavy sheath of the adult axis. In *Heracleum* its origin is definitely procambial, and the wavy nature of the sheath indicates origin from separate meristem units.

It is, therefore, concluded that no morphological value of a permanent nature can be attached to the starch sheath as a layer in the same sense as in the case of endodermis, and, as such, they should not be used as equivalents at least in the species studied.

Liverworts

23. Studies in Indian Hepaticae IV. The epiphyllous Hepaticae of India and Ceylon. Part II.

S. K. PANDÉ *and* S. AHMAD, Lucknow.

In Part I of this series six epiphyllous liverworts, including some new species, were reported (*vide* Misra, R. N., *Proc. Ind. Sci. Congress,* Lahore, 1939). In this paper four additional species are described.

1. *Taeniolejeunea peraffinis* (Schiffn.) Zw. Locality—Gersoppa Falls (Mysore State, South India, 1,500′). Habitat—on thick and leathery living dicot leaves.
2. *Leptocolea pseudofloccosa* Horikawa. Locality—Pedro's Peak (Ceylon). Habitat—on the upper surface of thick and leathery living dicot leaves.
3. *Radula protensa* Ldbg. Locality—Gersoppa Falls (Mysore State, South India, 1,500′). Habitat—on thick and leathery living dicot leaves.
4. *Leptolejeunea* sp. Locality—Gersoppa Falls (Mysore State, South India, 1,500′). Habitat—on living dicot and palm leaves. The species seems to be closely related to *L. Schiffneri* St. of Java.

The discovery of these liverworts from South India extends the range of distribution of these plants to India. Some observations regarding their taxonomy, etc., are also included.

24. Studies in Indian Hepaticae V.

S. AHMAD, Lucknow.

In this paper three Indian species of *Riccia* are described. One of these species grows in association with *R. himalayensis* Kash. and *R. melanospora* Kash. during the monsoon months at Lucknow. It shows superficial resemblance to *R. melanospora* and young and less vigorous plants of *R. himalayensis* but can be easily distinguished, even in the sterile condition, from the former, because of the absence of the cilia, and from the latter, because of its darker colour, less prominent scales and smaller and narrower thalli. The spore characters in all these species are also different.

The second species described here is based on the material collected by Dr. A. R. Rao from Mangalore and Bajpai (South India) in June, 1939. This is a non-ciliated species of *Riccia* and has apparently no scales. The latter if present must be rudimentary and fugaceous since they cannot be detected in the spirit material. The plant appears to be closely related to the species of *Riccia* described above, but the spores are very different and hence these represent two different but closely related species.

The third species of *Riccia* described in this paper was found mixed with a species of *Anthoceros* collected from the Western Himalayas. It is a ciliated plant and is, in this respect, related to *R. melanospora* Kash. but the general habit, the size of cilia and the characters of the spores of the two plants are very different.

All the species are new to Indian flora and are probably also new to science.

Fungi

25. Necrosis of roots of *Aloe vera* Linn.

A. B. BOSE, Calcutta.

Fusarium coeruleum (Lib.) Sacc. causes necrosis of roots of *Aloe vera* Linn. in Bengal. So far, there is no record of this species on roots of *Aloe vera*. The same species is reported to be the cause of the dry rot of potatoes in storage in India, England and other countries. The size of macroconidia ranges from $18–33 \times 3–6\mu$ and the average is $25 \times 5\mu$. The conidia-shape is oval to spindle, slightly curved and not hooked. The pathogenicity of the fungus has been firmly established by inoculation experiments on roots of living plants in the garden.

Various

26. Studies on the occurrence, structure and life history of *Micropoma*, sp. nov., occurring at Baroda.

V. G. PHATAK, Baroda.

A new species of moss belonging to the genus *Micropoma* is described in the present paper. This is the first record of the genus in India. It is a moss growing on the muddy banks of lakes, rivers, etc. The moss described grows on the banks of the Harni lake at Baroda. It is usually branched bearing two to four equal-length branches with leaves standing straight and having wavy and serrate margin. It is a gregarious light-green coloured moss.

The species of moss under consideration differs from *M. niloticum* (Lindb.) and also from *M. bukobense* (Broth.) in having a sporogonium which shows a small apophysis between the spore sac and the stalk. The apophysis is small celled, green and bears characteristic stomata. The genus *Micropoma* has a sporogonium without apophysis. It also differs from the two foreign species in having a calyptra with 4 lobes and not 3. The shape is tubular and not cap-like. The beak is borne towards one side of the tubular calyptra and is curved and blunt-tipped. The beak is also as long as the calyptra tube. In the foreign specimens it is bent and short. This Indian species may, therefore, be named *Micropoma Indica*.

27. A new plant from South Burma.

K. BISWAS, Calcutta.

It is well known to the systematic botanists that Craib while working out Meebold's collection of South Burma discovered many new species which were published in *Kew Bulletin, Fedde's Repatorium and Flora Siamensis* for some years. It was felt that while Craib was working out the flora of Siam, it would be worth investigating the flora along the borderland of Siam—now Thailand—and extreme South Burma, namely Kyenchaugh Forest area in Tenasserim, Mergui District. Considerable collections have already been made by the author with a view to detailed study of the flora of this interesting portion of the rain-forest formation in what may be called an uncharted area by three visits during 1930, 1931 and 1932. A peculiar Annonaceous plant—a tall shrub or what may be called a small tree—was discovered along the banks of Kyenchaugh Forest up to the Nam Sap area merging into the low hilly ranges of Thailand. The leaves of this plant growing in the shade of the forest were found coated with a brown silken woolly species of Alga (?). This plant has been found to be a new species which I name *Goniothalamus tenasserimensis* Biswas. It bears a similarity to *G. Meeboldii* Craib. This *G. Meeboldii* of Craib was doubtfully identified by him as he had only fruiting material at his disposal. Craib was not therefore quite sure about his generic identification. Subsequently King's collector and C. E. Parkinson collected from the Andamans and South Burma similar plants which appear to be specifically the same as *G. Meeboldii*. A description has been added of this new species together with notes on its occurrence in association with different storeys of vegetation in the rain forest of South Burma.

28. Observations on a common tree fern of the Eastern Himalaya.

K. BISWAS, Calcutta.

Considerable confusion was discovered as regards the correct systematic position of many species of Indian and Burmese ferns and fern allies during the examination of type, co-type and duplicate sheets in Kew, British Museum (Natural History) London, Edinburgh and Calcutta Herbarium. It is high time that the correct determination of the species should be established. In the present paper I have dealt with one of the most common tree ferns of the Eastern Himalayas which has been considered by different well-known Pteridologists as three different species if not four. My scrutiny reveals that there exists only one species, namely, *Cyathea spinulosa* Wall. and the rest are mere varieties or different forms which have developed under different ecological conditions. The confusion was evidently due to mainly herbarium work without much reference to the study of the plant in the field at different stages of its growth in different localities in India.

29. The algal flora of the hot springs of Vajreshwari.

(MRS.) E. GONZALVES, Bombay.

The springs are situated about fifty miles from Bombay. The paper includes the results of an investigation into the elements composing the algal flora of these springs. Algae were collected from the hottest spring, which has a temperature of about 59°C., as well as from other places with lower temperatures. A list of the various forms is given in the paper. Some forms have been found to endure a wide temperature variation.

The amounts of dissolved oxygen and organic matter were found to be less at lower than at higher temperatures. Free CO_2 was absent in all the samples. The *p*H ranged from about 6·8 to 8·2.

30. The chloride-content of the sea-water, soil-solution and the leaf cell-sap of some mangroves.

F. R. BHARUCHA *and* B. S. NAVALKAR, Bombay.

Recently Walter and his colleagues have shown that the zonation of the mangrove vegetation is largely due to the capacity of the plants to tolerate increasing or decreasing amount of chloride in the soil. Our studies confirm their observations and we have further shown that the chloride-content of the sea-water and the soil-solution depends upon the climatic factors, chiefly rainfall, temperature and relative humidity. These variations influence in turn the chloride-content of the leaf cell-sap and as such the latter variations are more influenced by climatic factors rather than by physiological.

31. The H-ion concentration of the sea-water, soil-solution and the leaf cell-sap of some mangroves.

F. R. BHARUCHA *and* B. S. NAVALKAR, Bombay.

With the study of the chloride-content of sea-water, soil-solution and leaf cell-sap the H-ion was also determined. These studies have revealed that the cell-sap is distinctly acidic, the soil-water nearly neutral and the sea-water distinctly alkaline.

The *p*H determinations have further shown that in the monsoon the leaf cell-sap becomes less acidic than in the rest of the year which might be due to less accumulation of sodium salts in the monsoon.

32. The osmotic pressure of the sea-water, soil-solution and the leaf cell-sap of some mangroves.

F. R. BHARUCHA *and* B. S. NAVALKAR, Bombay.

The determinations of the chloride-content and *p*H of the above three solutions were done with a view to find out which of them affects more the osmotic values of the cell-sap. Our experiments have shown that the O.P. is influenced by the chloride-content of the cell-sap which in turn depends upon that of the soil and sea-water. The latter, as shown in the first paper, is dependent upon the climatic factors and that therefore the O.P. is dependent indirectly upon the climatic factors. Our interesting feature of these investigations is the sudden rise in the O.P. in the cold season, namely, at the end of December or beginning of January.

SECTION OF ZOOLOGY

President:—H. SRINIVASA RAO, M.A., D.Sc., F.A.Sc., F.N.I.

Protozoa

1. On some Microsporidia including a new form from anopheline larvae.

P. SEN, Calcutta.

Microsporidian infection has been recorded from seven species of Anophelines, *Anopheles hyrcanus nigerrimus*, *A. annularis*, *A. ramsayi*, *A. varuna*, *A. sundaicus*, *A. subpictus* and *A. vagus*. Three species of Microsporidia, *Thelohania legeri* Hesse, *T. indica* Kudo and *T. anomala* sp. nov., were concerned in the infection. The last named species is described fully for the first time. The other two species of *Thelohania* have already been recorded by Kudo (1929) from Indian anophelines, and his observations on these two species are confirmed. *T. anomala* sp. nov., with its eight to twelve sporoblasts, closely agrees with an unnamed species of *Thelohania* reported by Missiroli (1929), but differs in the measurement of the spores. The spores in the new species are 5·1 to 6·1μ long and 2·0 to 2·1μ broad whereas in Missiroli's form the spores are only 3 to 4μ long.

2. Observations on an undescribed species of intestinal flagellate (*Tetratrichomastix*), from the skipping frog, *Rana limnocharis* Meig.

P. L. MISRA, Lucknow.

An examination of half a dozen specimens of *Rana limnocharis* collected near Mukteswar-Kumaun revealed that this host harbours besides various other protozoan parasites, a flagellate which showed the characters of the genus *Tetratrichomastix* Young, 1935. This is the first record of the genus *Tetratrichomastix* from India and *T. hegneri* sp. nov. represents the second species to be described from a vertebrate host, the first being *T. citelli* Becker, 1926, from the ground squirrel *Citellus tridecemlineatus*.

The body of *T. hegneri* is irregularly pyriform showing apparent bilateral symmetry and is (exclusive of the free axostylar portion) 5·6μ–10·3μ long and 2·8μ–5·6μ wide. The periplast is distinct and a cytostome is present. Five flagellae originate from a single basal granule, of which four are equal and anteriorly directed while the fifth is longer than the rest and forms the 'schleppgeissel'. The rhizostyle is absent. The nucleus is more or less spherical, 1·4μ–2·7μ in diameter, and contains a centrally located endosome. The cytoplasm is vacuolated and contains bacterial inclusions. A few specimens were invaded by the micrococcus *Sphaerita* sp. Multiplication takes place by longitudinal fission. Cysts are spherical, and 4·8μ–6·3μ in diameter.

A discussion regarding the taxonomic characters of the trichomonad flagellates and a comparison of the species of *Tetratrichomastix* hitherto described are also included in this paper.

Porifera

3. Observations on the gemmule development of *Chalina* sp. with a note on dissociation and regeneration in the same species.

V. R. SIVARAMAKRISHNAN, Madras.

1. *Gemmule development in* Chalina *sp.*

A preliminary account of the development of the larva of *Chalina* from gemmules is given in this paper. *Chalina* reproduces throughout the year by means of these asexual bodies. In the adult sponge, the complete organization is devoted for the production of gemmules. A single gemmule is formed by the congregation of numerous yolk laden amoebocytes which enter into intimate association with differentiated collar cells. The transformation of the gemmule into the larva is effected by the rearrangement of cells already present inside it. The collar cells get placed along the periphery to form the ciliated larval epithelial cells. A small portion of the gemmule is left non-ciliated which forms later the posterior pole of the larva. A brownish black pigment ring is formed between the anterior ciliated region and the posterior non-ciliated pole. Fully formed larvae breaking open the gemmule envelope get free into the surrounding water. The larva belongs to the amphiblastula type. A description of the free swimming larva is also given.

2. *A note on the dissociation and subsequent regeneration in* Chalina *sp.*

The sponge is cut up into tiny bits. These bits are gently squeezed inside a bag of fine muslin cloth. The expressed cells are allowed to fall into petri dishes containing clean sea water. The epidermal cells do not come out in the expressed mass. The amoebocyte fuses with the neighbouring cells by means of pseudopodia and forms cell groups. The choanocyte cells withdraw their collar and flagellum. The cell groups in turn unite with adjacent ones and small spherical masses of sponge cells are produced. In about two days' time these tiny growing spherical masses assume 1 mm. to 2 mm. size. These spherical masses attach to the substratum by coarse reticula and give rise to small encrusting sponges.

Coelentarata

4. On three undescribed species of *Coeloplana* from Krusadai island, Gulf of Manaar.

D. W. DEVANESEN *and* S. VARADARAJAN, Madras.

I.

Coeloplana tattersalli sp. nov.

Distinguishing characters: (1) Only eight aboral papillae which appear as diverticula; (2) the polar-field is on a hump; (3) the animal is translucent suffused with green; and (4) it is a free-living form. *Bionomics:* When a few living copepods were added to the aquarium, the animal became conscious of their presence, because the latter darted to and fro and produced disturbances in water to which the former responded; for it moved briskly, throwing out its tentacles, making definite acts at capturing the prey, reminding one of an animal which stalks its victim. The specific name is given in honour of Prof. W. M. Tattersall who discovered this aberrant ctenophore at Krusadai on 7th February, 1938.

II.

Coeloplana indica sp. nov.

Distinguishing characters: (1) The number of papillae reduced to 8; (2) papillae knob-shaped; (3) their arrangement in two rows of four distributed at regular intervals, parallel to the tentacular axis; (4) a uniform grey colouration; and (5) a free-living form. A single specimen. Very rare.

III.

Coeloplana krusadiensis sp. nov.

Distinguishing characters: (1) The aboral papillae vary from six to over twenty; (2) a uniform brick-red colouration; (3) lives in association with the star-fish *Pentaceros hedemanni*. The maximum number found on the aboral surface of a single star-fish varied from 50 to 60; yet no incomplete specimens were found.

Annelida

5. Note on the occurrence of Archiannelids at Krusadai together with a description of an undescribed species of Saccocirrus.

K. H. ALIKUNHI, Madras.

Examination of the inter-tidal sand at Krusadai during September, 1940, revealed the presence of *Polygordius madrassensis* Aiyar and Alikunhi, *Protodrilus pierantonii* Aiyar and Alikunhi (*Proc. Ind. Sc. Congr.*, 1940. Full paper in Press) and a new species of *Saccocirrus*. *Protodrilus* was obtained from Pamban only along with *Saccocirrus*, while the latter and *Polygordius* were collected from 'Sandy Point', Krusadai. This is the first record of Archiannelids from Krusadai.

Saccocirrus krusadensis sp. nov. occurs in considerable numbers. The worm is 20 to 25 mm. long with 100 to 150 segments. Pygidium is forked, each lobe carrying 6 to 9 adhesive papillae. In each parapodium there is one or two long slender furcate seta with markedly unequal prongs. A muscular pad is developed in the pharyngeal wall, much the same as in *S. papillocercus*. In more than 50 specimens examined the gonads in either sex were developed only on one side, usually the left. Corresponding to this the sperm-sacs, penes, and spermathecae were found only on the same side. The sperm-sacs are situated in the median chamber of the body cavity. The penis is elongated, cylindrical and protrusible. The spermathecae contain spermatozoa. Mature ova pass down the nephridial duct which is capable of dilatation. Fertilization probably takes place at the point of union of the nephridial and spermathecal ducts.

To the genus *Saccocirrus* the following four species have so far been ascribed—*S. papillocercus*, *S. major*, *S. minor* and *S. cirratus*. The peculiar furcate seta, the number of adhesive papillae, the one-sided nature of the gonads, the position of sperm-sacs in the median chamber of the body cavity, and the shape of the penis together with other features mark out *S. krusadensis* from the other species of the genus.

6. On an undescribed hermaphrodite species of *Microphthalmus* (Hesionidae) occurring on the sandy beach at Madras.

K. H. ALIKUNHI, Madras.

Of the four known species of *Microphthalmus*, *M. sczelkowii*, *M. aberrans*, *M. similis* and *M. fragilis*, the last two are hermaphrodite, while nothing is known regarding the reproductive organs of the other two. The new Madras species is also a hermaphrodite. In view of Bobretzky's meagre description of *M. fragilis* and *M. similis* and the difference between the Madras *Microphthalmus* and *M. sczelkowii* and *M. aberrans*, it has been considered advisable to describe the Madras worm as a new species.

M. urofimbriata sp. nov. occurs in fair numbers. Specimens 6 to 8 mm. long have 40 to 75 setigerous segments. Cephalic appendages are well developed. The two eyes are forwardly placed. Nuchal organs are conspicuous. Parapodia are biramous the dorsal division carrying 12 to 18 capillary setae including the pectinate seta. Simple and compound setae are present in the ventral division. The anal plate has 20 to 30 finger-shaped processes on the margin. Male reproductive organs occupy the anterior and female reproductive organs the posterior segments. The two penes, situated between segments two and three have cuticular supporting rods. A pair of male genital ducts runs forwards from the anteriormost testis segment to open at the base of the penes. In each female segment is a pair of receptacula seminis. Transference of sperms probably takes place during copulation.

The arrangement of the cephalic appendages, the nature of the setae, the fimbriated anal plate, the cuticular supporting rods of the copulatory organs, the elongated vasa deferentia, and the absence of intermingling of the sexual elements are some of the important features characteristic of *M. urofimbriata*.

7. On an undescribed species of *Myzostoma* from the Madras harbour with a note on the occurrence of *Myzostoma adhaerens* Remscheid.

A. I. GEORGE, Madras.

This is a very elegant form occurring on the Crinoid *Lamprometra palmata* Clark. The elliptical body is adorned with two pairs of longitudinal violet brown bands on an orange-white ground colour.

Dorsal surface is convex with a median longitudinal crest. In addition there are several shorter ones radiating from it. Margin carries ten pairs of cirri and three pairs of prominent caudal appendages. Cirri are short triangular processes and never exceed twenty in number. The ramifications of the intestine and the ovary extend into and completely fill the caudal appendages. Parapodia suckers, male genital papillae, mouth and cloaca are ventral in position. Parapodia are highly muscular. Each parapodium has a thick conical base and a slender elongated distal portion. Suckers are prominent with complicately folded walls. Mouth opening is sub-terminal. Pharynx is slightly protrusible and has four papillae. Pharynx is provided with a bulbus musculosus. Two pairs of intestinal diverticulae originate from the baggy stomach. Cloacal opening is sub-terminal. A large stellate nervo-ganglion is present ventral to the alimentary canal.

M. adhaerens Remscheid was also obtained by the author along with *M. striata*. These are small disc-shaped forms with numerous marginal cirri. Minute tubercles abound on the dorsal surface. There are four small caudal appendages. The only other Myzostome recorded from the Madras coast is *M. gopalai* Subramaniam.

8. On the occurrence of hermaphroditism in *Sabellastarte magnifica* Shaw together with an account of the excretory organs in the species.

V. RUNGANATHAN, Madras.

The paper gives an account of the occurrence of hermaphroditism in *Sabellastarte magnifica* Shaw, a Sabellid Polychaete worm that occurs in the Madras harbour. Examination of the living worm shows well-developed motile sperms and immature ova floating in the coelom. It is suggested that the worm is protandrous as when fully developed ova are present mature sperms are nearly always absent.

In addition to the single pair of thoracic organs with a median opening which are present in most of the Sabellids, ordinary nephridia are present in the middle and posterior regions of the body as has been described by various authors. Each nephridium is in the form of a trumpet-shaped structure. It does not pierce the septum and reach the next segment but lies in the thickness of the septum with the trumpet like funnel placed in the angle between the alimentary canal and the septum and the external pore having an intersegmental position. The nephridia act as genital passages and probably also as excretory ducts.

9. Multiple funnels of nephridia in the Oligochaeta.

K. N. Bahl, Lucknow.

Many earthworms with multiple nephridia are known, but I am recording two cases in which a single nephridium is provided with a large number of funnels. The first is that of the nephridia of *Thamnodrilus crassus*, a giant earthworm from Ecuador in which multiple funnels were first noticed by Pickford. Each nephridium of this earthworm is provided with more than 30 funnels. The second case is that of *Hoplochaetella* from Bombay in which each nephridium is provided with a large functional funnel and 25 to 30 small but complete funnels with solid necks. Evidently these latter funnels are vestigial.

10. On the embryonic nephridia of the cattle leech *Hirudinaria granulosa*.

M. L. Bhatia, Lucknow.

Seventeen pairs of metamerically located nephridia perform the excretory function of *Hirudinaria* in the adult condition, but during developmental stages the excretory material is eliminated by *four pairs* of the so-called 'embryonic nephridia'. In *Hirudinaria* as in *Aulostoma* and *Nephelis* (Sukatschoff, 1900) the embryonic nephridia arise from a few cells at the posterior extremity of the embryo. Each nephridium consists of an irregular and delicate string of a single row of cells which are traversed by an intra-cellular canal. At one end of the canal there is an internal opening leading into a thimble-shaped funnel, while at the other there is a circular external opening. The funnel has a protoplasmic fimbriated border composed of pseudopodia-like processes.

The embryonic nephridia later dwindle and ultimately disappear when the adult nephridia begin to function.

Platyhelminthes

11. On an undescribed species of *Aspidogaster* from the intestine of the fresh-water fish, *Barbus tor* (Ham.).

J. Dayal, Lucknow.

A large number of trematodes collected from the intestine of the fresh-water fish, *Barbus tor*, were found to differ from all the known species of *Aspidogaster*, in the anterior position of the genital pore, in the possession of a petaloid cirrus, in the relative position and size of the genital organs and in the larger number of alvooli on the ventral disc.

A detailed account of the anatomy of the new form, *Aspedogaster indicum* sp. nov., is given in the paper.

12. On an undescribed species of Avian cestode from Dharwar, India.

N. B. INAMDAR, Dharwar.

In this paper is described a new species of *Shipleyia* Fuhrmann, 1908, from the intestine of a Black-winged Stilt, *Himantopus himantopus* (Linnaeus). This species differs from the only known species of the genus, *Shipleyia inermis*, in the presence of irregularly alternating genital pores and in size. The new species is named *Shipleyia farrani*.

13. On the taxonomy of some species in the genus *Avitellina* (Cestoda).

MOHAMMAD AMIN, Lahore.

The author, in this paper, suggests that *Avitellina southwelli* Nagaty and *Avitellina sandgroundi* Woodland are identical with *A. centripunctata* (Rivolta), and discusses the specific characters employed for the discrimination of those species, e.g. size of the segment; crowding of testes, ovaries and uterine organs; position of a row of testes external to ventral excretory canal; situation of cirrus-sacs in the same dorso-ventral plane as the vulvae; side to side alternate arrangement of uteri; and tortuous course of ventral excretory canals. These structural peculiarities appear to be the result of muscular contraction and are, therefore, of little taxonomic value.

14. Paramphistomid parasites of oxen and buffaloes in Lahore.

N. K. GUPTA, Lahore.

This paper deals with the systematics and anatomy of the Paramphistomes occurring in oxen and buffaloes of Lahore. The specimens were obtained from the Lahore Abattoir. Three species of the genus *Paramphistomum* have so far been met with and studied by the present writer, viz., *Paramphistomum cervi* (Zeder), *P. explanatum* (Creplin) and *P. crassum* (Stiles and Goldberger). *P. cervi* is the commonest of the three, and occurs very frequently in the bile ducts of buffaloes. *P. explanatum* appears to be comparatively rare, although previous authors have recorded them as very common. *P. crassum*, found in the rumen of buffaloes, is also rare.

The anatomy of *P. cervi* and *P. crassum* has been described and their taxonomy discussed in the paper.

15. On two helminths of *Mastacembelus pancalus* (Ham.) including a new record of *Azygia* from India.

G. D. BHALERAO, Izatnagar.

The trematode *Azygia angusticauda* (Stafford, 1904) is recorded from the liver of *Mastacembelus pancalus* obtained from Fuleshwar (Bengal). This is the first record of a species of the trematode genus *Azygia* from India. Observations are made on the anatomy of the parasite and one abnormal form is described.

A larva of *Gnathostoma* sp. was found encapsuled in the coelomic cavity of the fish.

16. On the need for a revision of the genera of Holostome trematodes described from India.

G. D. BHALERAO, Izatnagar.

The writer recounts 48 species of 'Holostomes' from this country and points out the shortcomings in the descriptions of several of them and the wrong taxonomic position assigned in many cases. His object in presenting this communication is to stimulate re-examination of the already described species with a view to provide missing links in the descriptions and the correct interpretation of some of the structures. The metacercarial form *Strigea annandeli* Faust has been shown to be wrongly assigned to the genus. *Neoalaria thapari* Lal has been assigned to *Diplostomum*, *Glossodiplostomum hieractii* Vidyarthi (Syn. *G. buteoides*) to the newly created genus *Glossodiplostomoides*, *Pharyngostomum bagulum* Lal to *Neodiplostomum*, *Crassiphiala ceryliformis* Vidyarthi and *C. stunkardi* Pande to *Uvulifer*, and *Proalarioides tropidonotis* Vidyarthi to *Travassosstomum* Bhalerao. The possibility is indicated of *Proalaria grayii* Verma being a member of a new genus. The new genus *Glossodiplostomoides* differs from *Glossodiplosmum* in having a more marked difference between the fore- and the hind-body, the latter being at least twice longer than the former, the hold-fast organ being larger and the genital organs occupying more body space. In most other cases the author has accepted the conclusions arrived at by Dubois.

17. Some metacercarial forms of Clinostomidae (Trematoda) from India.

G. D. BHALERAO, Izatnagar.

The author describes a new species of *Euclinostomum*, three new species of *Clinostomum* and records the species *C. piscidium* Southwell and Prashad. *E. indicum* n.sp. differs from *E. heteroporum* in the extent of the uterine sac and the utero-duct and in the ratio of the two suckers. *C. prashadi* n.sp. differs from *C. piscidium* in the body being thin and elongate, the ratio of the two suckers, the position of the gonads and the extent of the vitellaria. *C. dasi* n.sp. differs from *C. chrysichthys* in the position of the gonads and in the position of the point of union of the utero-duct with the uterine sac. *C. gideoni* n.sp. differs from *C. chrysichthys* in respect of the point at which the uterine duct joins the uterine sac, the nature of the testes and in the position of the genital pore which is situated level with the middle of the anterior testis.

Pharynx was found to be present in *C. piscidium*.

18. The genus *Cephalogonimus* in India and Burma.

G. D. BHALERAO, Izatnagar.

Of the six species of *Cephalogonimus* recorded from India and Burma, *C. emydalis* would appear to be very variable and *C. magnus* (Syn. *C. gangeticus*) a variety of *C. emydalis*. *C. mehrai* and *C. minutum* are considered to be valid species. *C. burmanica* is provisionally accepted to be different from the other species of the genus. Various organs subject to variation are considered in the case of these species.

Nemathelminthes

19. Observations on *Syphaciella indica* Maplestone (Nematoda) from Hyderabad (Deccan).

S. N. SINGH, Hyderabad-Deccan.

This species of the nematode worm was described by Maplestone in 1931 from a Sand Grouse, *Pterocles exustus* (Temm.) which died in the Calcutta Zoological Gardens. On two occasions the author obtained numerous specimens of this species from the same host in Hyderabad (Deccan). In this paper a detailed account of this worm is given, and more particularly, of the female reproductive organs.

Chaetognatha

20. On the arrow-worms of Krusadai.

S. VARADARAJAN *and* P. I. CHACKO, Madras.

The Arrow-Worms from Krusadai plankton are described with reference to their specific characters, bionomics and seasonal distribution. All the three genera, *Sagitta*, *Spadella*, and *Eukrohnia* are met with in the plankton. *Spadella cephaloptera* and *Eukrohnia pacifica* which are new records from this area are described. It is noticed that this is the first time that *Spadella cephaloptera* is correctly recorded from Indian waters. Four species of *Sagitta*, viz., *Sagitta enflata*, *Sagitta tenuis*, *Sagitta robusta*, and *Sagitta neglecta* are described from Krusadai, the first two species being abundant. Double headed monsters of *Sagitta* and their cannibalistic tendencies have been noticed. These arrow worms are indicators of water current movements which have a bearing on fishery problems. They also form a considerable part of the food of certain fishes and hence the study of their seasonal occurrence is important. As observed in other localities, all the different species of *Sagitta* are found living together. The Arrow-Worms found at Krusadai are probably those which drifted northwards from the Gulf of Manaar into the Palk Bay. The situation of Krusadai in the path of this current is noteworthy.

Nemertinea

21. On the anatomy, histology and ecology of *Eupolia* sp. (Nemertinnea) from the Karachi coast.

(MISS) EVA NATHAN, Lahore.

The material for the present paper was collected from Manora Island, Karachi, during December, 1940. All the specimens belong to the same species of *Eupolia*. The paper contains an account of the anatomy and histology of the species with notes on its ecology. The author has also discussed the systematic position of the species.

Mollusca

22. A preliminary account of the development and disintegration of the shell-gland in *Pila globosa*.

S. NAGA RAJA, Annamalainagar.

The embryonic shell-gland arises in the typical manner found in Mollusca. In the early veliger stage the shell is a thin cuticular, cap-like structure. The mantle edge, which is formed from the peripheral part of the shell-gland develops groups of gland cells at intervals which appear as if they were mantle processes. These may be called embryonic marginal shell-glands. They form a very striking feature of the late veliger stages. The shell in these stages shows very narrow, zig-zag suture-like bands which are spirally arranged and correspond in number and position to the prominent embryonic shell-glands, and in fact arise from them. The marginal shell-glands are probably entirely responsible for the secretion of the shell at this stage. They open into what corresponds to the supra-marginal groove of the adult. Meanwhile the definitive shell-glands are differentiated. At the time of hatching the embryonic marginal shell-glands degenerate and only vestiges of them are seen. In the adult mantle they disappear altogether. Further work is in progress.

Enteropneusta

23. Balanoglossids as food of fish.

D. W. DEVANESEN *and* P. I. CHACKO, Madras.

Sillago sihama, Mugil waigiensis, Mugil troschelii and *Therapon jarbua* are the fishes represented in the catches made by stake-nets from the *Balanoglossus*-area, Krusadai Island. Only 10% of the whiting and 12% of the squeaking perch examined included Balanoglossids in their diet. These either dig into the burrows of Balanoglossids, pull them out and eat them or capture such of the worms as are exposed by the waves.

In spite of these known enemies, no apparent reduction in the population of Balanoglossids is noticed. Thanks to the comparative freedom the *Balanoglossus*-bed of the tidal zone enjoys, sea-water can cover it only during the high-tides, twice during 24 hours. The two fishes in question are therefore deprived of access to the bed at low-tides; their ravages are intermittent as they have to retire with the ebbing tide. The Balanoglossids involved in this research are (1) *Chlamydothorax* (= *Ptychodera*) *krusadiensis* and (2) *C.* (= *Ptychodera*) *ceylonensis*. The snout of the specimens of *Sillago sihama* and *Therapon jarbua* which have fed on Balanoglossids smells of iodoform. *Balanoglossus* is not an item of food of the mugils which forage in that area, thereby furnishing an example of eclecticism in diet among fishes.

Tunicata

24. On the digestive glands of Monascidians.

S. M. DAS, Lucknow.

In a memoir on *Herdmania* (1936) the author wrote: 'It is probable, therefore, that all ascidians with a distinct liver store carbohydrate in the form of starch while those with no liver store it in the form of glycogen.' The only genera in which the digestive glands had been examined for stored carbohydrate, till then, were *Pyura, Herdmania,* and *Ciona*. Garstang raised the objection that these genera were too closely allied to make a broad generalization of the nature published by the author. The present paper gives a comparative account of the digestive glands in *Herdmania, Molgula, Styela, Phallusia, Ascidia,* and *Ciona,* forms belonging to widely divergent families, and substantiates the author's earlier view by demonstrating the presence of starch only in those genera which possess a distinct liver. The author has also shown that the Tunicata could be divided roughly into two main classes; in one the members have a well-defined liver (e.g. *Pyuridae, Molgulidae*) and in the other the members have no definite liver (e.g. *Phallusidae, Botryllidae*).

25. The neuro-muscular system of the test in Tunicata.

S. M. DAS, Lucknow.

It is common knowledge that the test of ascidians is contractile and more particularly in the monascidians. The siphons are highly sensitive and contract if touched, or if the water in which the animal lies is disturbed, shooting out two jets of water. The author described in *Herdmania* (1936) the mechanism of this reaction to external stimuli, and demonstrated the presence of receptor cells and nerve cells as well as muscle and nerve-fibrils in the test. The present paper gives a comparative account of the test in *Molgula, Styela, Phallusia, Ascidia* and *Ciona*. It is established that a neuro-muscular system is present in the test of all these genera and is comparable to that found in *Herdmania*.

Pisces

26. Respiratory adaptations of the South Indian Homalopterid fishes.

S. L. HORA *and* N. C. LAW, Calcutta.

The respiratory movements of *Balitora* and *Hemimyzon* are discussed and correlated with the habitat and form of the fishes. It is shown that the movements of the inner rays of the pectoral fins are not associated with respiration. The probable causes which may have led to the reduction of gill-openings, to the formation of receptacles for storage of water, and to the periodic suspension of respiratory movements are explained. Attention is directed to the close parallelism between the accessory respiratory chambers of the Homalopteridae and the bucco-pharyngeal chambers of certain air-breathing fishes of India. An account of the lips and associated structures of the Homalopteridae of South India is given and the probable functions of the various structures explained. Suggestions are made for further work in the respiration of these fishes, especially in regard to their serving as accessory chambers for aerial respiration.

27. Results of a preliminary fish-survey of the Pochārām Lake.

M. RAHIMULLAH, Hyderabad-Deccan.

In this beautiful lake situated about 80 miles from Hyderabad city, and formed by building a dam across Alair river, a fish-survey in different parts of the lake, in the canal and surrounding ponds and tanks below the dam which are connected with it only during the rainy season, revealed the occurrence of 25 species of fish, belonging predominantly to the genera *Rohtee*, *Ambassis*, *Gobius*, *Barbus* and *Lepidocephalichthys*.

Some other interesting points regarding the lake and its fauna are also mentioned in the paper.

28. On some stages in the early development of *Arius jella* (Cuv. and Val.).

V. K. THIYAGARAJAN, Madras.

The present paper deals with the detailed development of *Arius jella* of the Adyar brackish waters from the earliest stages to the closure of the blastopore. For convenience of description the details are given under five stages.

Stage I.—The blastoderm is a circular patch about 1 mm. in diameter forming a cap of cells at one pole of the yolk.

Stage II.—The blastoderm has expanded to about 2·5 to 3 mm. An invagination of the inner layer of the epiblast along the entire margin of the embryonal area establishes the primary hypoblast which holds the material for the formation of the mesoblast, the notochord and the endoderm.

Stage III.—The embryo measuring about 1·5 mm. stretches forward from the posterior pole of the blastodisc. Anteriorly the inner cell layer of the epiblast along the median line has thickened to form the solid neural keel while the primary hypoblast is getting separated into the mesoblast, the notochord and the endoderm. At the posterior end is present a mass of undifferentiated cells inside which the Kupffer's vesicle now appears.

Stage IV.—The rim of the blastodisc has just reached the equator of the egg. The embryonic streak now measures about 3 mm. Near the anterior end the two optic vesicles have grown out from the neural keel. About 13 to 14 myotome segments have been established. The endoderm layer has not yet folded itself to form a tube—the future alimentary canal.

The Kupffer's vesicle can still be made out at the hind end in the region of the neurenteric streak.

Stage V.—The closure of the blastopore occurs at this stage at a distance of about 2 mm. behind the formed tail fold of the embryo which measures about 5 mm. In this respect the present form resembles very much the condition described in the toad-fish Batrachus (Clapp, *Journ. Morph.*, 1899).

29. Preliminary observations on the nidamental glands of some elasmobranch fishes of the Madras coast.

R. RAGHU PRASAD, Madras.

The paper deals with the structure of the nidamental glands of an ovo-viviparous form, *Rhinobatus granulatus* and two viviparous forms, *Scoliodon palasorrah* and *S. sorrakowah*. It is known that the nidemental gland is best developed in oviparous forms like *Scyllium canicula* and *Chiloscyllium griseum* and consists mainly of three parts, the albumen mucus- and shell-secreting zones. In *R. granulatus* it is noticed that the mucus-secreting zone has disappeared. In the viviparous *S. palasorrah* the mucus-secreting region has disappeared and the albumen-secreting zone is greatly reduced. In *S. sorrakowah* both mucus- and albumen-secreting tubules have disappeared, the shell-secreting region being represented by a few short tubules only. The entire gland is absent in *Narcine* and *Trygon*. Viviparity in the Odontaspidae and the Hypotremata has probably been acquired independently and the regressive changes noticed in the structure of the nidamental gland in the former family are also likely to be met with in the Hypotremata.

About the fertilization in the Elasmobranchs the general belief has been that it takes place in the upper reaches of the oviduct. Metten demonstrated that in the Dog-fish *Scylliorhynus canicula* the nidamental gland acts as a receptaculum seminis and that fertilization takes place in the lumen of the gland. Further evidence is brought forward in this paper to show that this is so in other forms such as *S. palasorrah* and *S. sorrakowah.*

30. Observations on the protective envelope of some viviparous elasmobranch fishes of the Madras coast.

R. GOPALA AIYAR, Madras.

This paper gives a comparative account of the nature of the egg case in a number of Elasmobranchs of the Madras coast. Details are given in regard to size, structure, shape and formation in such forms as *Chiloscyllium griseum*, *Rhinobatus granulatus*, *Pristis cuspidatus*, *Scoliodon dussumieri*, *S. palasorrah* and *S. sorrakowah*.

31. On the hatching of fish-eggs in 1940-41 in the laboratory of West-Hill Biological Station, Calicut.

D. W. DEVANESEN *and* S. VARADARAJAN, Madras.

Five types of fish-eggs are described, viz., (1) the Anchovy (*Engraulis*), (2) the White-Bait (*Stolephorus*), (2) the Seer-fish (*Scomberomorus*), (4) the Horse-Mackerel (*Caranx*), and (5) the Malabar Sole (*Cynoglossus semifasciatus*). The hatching experiments in regard to three types of eggs were maintained for three days. The eggs of the Anchovy, *Engraulis hamiltonii* (Gray) are without an oil-globule and a perivitelline space. The larvae of a Seer-fish hatched in the laboratory were checked with Seer-fish larvae in the plankton. The elongated eggs of *Stolephorus heterolobus* are elliptical without a knob and have a small yellow oil-globule. Seven kinds of Horse-Mackerel eggs are described. The transparent ovarian eggs of *Cynoglossus semifasciatus* are described. In addition to the measurements of eggs, descriptions of the stages of embryos and larvae, of the appearance of the paired fins, and of the pigmentation and number of myotomes are given.

32. On situs inversus viscerum in *Ophicephalus punctatus* Bloch.

L. S. Ramaswami, Mysore.

Situs inversus viscerum was observed in sixteen *per cent* of a population of *Ophicephalus punctatus*. The mirror-imaging has affected the blood vascular and alimentary systems. This must be due to the formation of twins and separation later, when in one of them the orientation of the viscera is opposite of the normal; it was not possible to secure double frys for verifying this.

33. On two interesting types of cement glands in S. Indian Teleosteans with a discussion on the homology of vertebrate cement glands in general.

S. Jones, Trivandrum.

Cement glands are found as larval adhesive organs in the Ganoidei, Teleostei, Dipnoi and Anura, and there have been two views regarding their homology. The first view is that these organs are homologous with the premandibular head cavities of other vertebrates, since they take their origin as endodermal pouches in the premandibular region in the Ganoidei, though they are of ectodermal origin in the other groups. The second view is that they are only analogous organs that have risen independently in the different groups. This view is supported by the absence of the glands in Cyclostomes and Elasmobranchs, and by the origin of the glands from different germ layers in the different groups. The discovery of two very interesting types of cement glands in two South Indian Teleosteans, have helped to prove that cement glands in vertebrates cannot be considered as homologous organs, but only as analogous organs that have risen independently in the different groups.

34. Preliminary observations on the fish-fauna of the Nizam Sagar area, Hyderabad State.

B. K. Das, Hyderabad-Deccan.

About 98 miles due slightly north-west of the city of Hyderabad is situated a very large artificial lake known as the Nizam Sagar. This lake is formed by the construction of a large dam (about 2 miles in length) across the river Manjira (one of the tributaries of the R. Godavari), which has a meandering course of nearly 390 miles within the State. The lake holds a maximum capacity of 30,000 million cu. ft. of water, with a depth of 106 ft. The average rainfall of the area is 31·9 inches per annum. Surplus amount of water is occasionally released from this lake by means of a series of flood-gates and sluices. The water from this lake is let out through a long canal mainly for irrigation purposes in the neighbouring areas.

In the original course of the river there are plenty of rocky beds (with boulders and pebbles), which are being fed by and filled with clear water overflowing the lake, thus converting them into so many deep, clear water pools that harbour the fishes. Other details of the ecological conditions of the lake have been fully discussed.

Large number of fishes have been captured by ordinary circular nets and dynamites. In all 27 species of fishes have so far been collected, belonging to 15 genera and 5 families.

35. Occurrence of late eggs in *Salmo fario* Linnaeus.

NAZIR AHMAD, Lahore.

In the present paper the author describes two types of late eggs found in the ovary and the coelome of *Salmo fario* Linnaeus collected from the Mahili hatcheries, Kulu, Punjab. The stripping period in the hatcheries extends from November to February, but the ova in question were collected in the middle of April. The two types of eggs differ in size, colouration, structure and behaviour.

36. Rate of growth in the first year of life of *Labeo rohita* and *Catla catla* in the different districts of Orissa.

G. N. MITRA, Cuttack.

The spawning season of *Labeo rohita* and *Catla catla* is known. In Orissa the fry are available in July and August. Representative samples of these fish have been weighed and weight curves drawn in graphs. Rate of growth in the first year and the variation in different districts of Orissa have been traced. The result is of economic value as it gives an indication to pisciculturists of the normal growth to be expected in the tanks in which they live.

37. A new method of transport of fish fingerlings.

G. N. MITRA, Cuttack.

Fish fingerlings are usually conditioned for a period varying from 12 hrs. to 4 days and transported in open vessels with frequent changes of water. Such a method is expensive in that a man has to accompany the consignment. By sealing fingerlings in a suitably designed vessel along with oxygen, fish can be transported as ordinary parcels. Details of experiments conducted are described.

Amphibia

38. The Sertoli cells in Apoda.

B. R. SESHACHAR, Bangalore.

The Sertoli cells of the testis, which in other vertebrates are believed to provide attachment and nourishment to the developing sperms, are not found as such in the Apoda. This is due to the great enlargement of the locules of the testis with the result that cell groups, including sperm groups, become scattered in the fatty matrix that fills the locule and are dissociated from one another.

But in the periphery of the locule of the testis occur cells, which, by their origin and structure recall the cells of Sertoli. But their function is doubtful. They provide neither attachment nor nutrition to the developing sperms. Probably developing spermatozoa obtain nourishment from the fatty matrix that surrounds them on all sides.

39. On the development of the vertebral column in Gymnophiona.

H. K. MOOKERJEE, Calcutta.

In Gymnophiona the notochord has two sheaths instead of one as stated by the previous workers. The skeletogenous layer remains sclerotomic in the intervertebral regions and not fibrous, contrary to the opinion of the previous workers. The ultimate centrum is formed as a thick membrane bone on the aggregation of the skeletogenous layer on the primary centrum including the united basiventralia to its caudal portion, which no previous worker has recorded up to now.

Each neural arch has three portions: (*a*) anterior connective tissue, (*b*) middle cartilaginous, (c) posterior connective tissue, a fact which no previous worker has recorded. That the middle cartilaginous arch has a deflected cartilaginous roof with a third piece, the *supradorsal*, which could be discriminated from the nuclear differentiation is also recorded for the first time.

The cartilaginous part of the neural arch together with the inner perichondrial layer degenerates, having only the outer perichondrial layer. The anterior connective tissue, the middle outer perichondrial layer and the posterior connective tissue of each neural arch become the primary membrane bone element, a fact which no previous worker has so far observed. Sclerotomic cells aggregate on the outer side of the primary membrane bone elements as plaster which also turns to plastering membrane bone forming secondary or ultimate neural arch which has not been recorded.

Between the occipital and atlas arch proper there is a pair of intercalated cartilaginous arch which extends laterally. A strand of migratory connective tissue cells cuts the intercalated arch into a ball and a socket. The path of the cells looks like an inverted 'W'. The formation of the synovial cavity by a split in the migratory cells from outside inwards has also not been observed before.

The peculiarities of the development of the ribs and its processes are recorded for the first time. The change in the position of the diapophysis from the right angular condition in the 2nd vertebrae to a parallel condition in the 7th and the following vertebrae in relation to the basidorsal is recorded for the first time.

The haemal arches of the tail vertebrae do not exist as stated by the previous workers.

40. A note on the occurrence of cartilage in the heart of a toad.

B. THIRUMALACHAR *and* T. SUBRAMONIA PILLAI, Mysore.

The occurrence of cartilage in the cardiac tissue of various vertebrates is well known, but its occurrence in the Amphibia has not been hitherto recorded. The authors describe cartilaginous nodules embedded in the septum medianum of the heart of the toad, *Bufo melanostictus*. They suggest that the nodules may serve the same purpose as the aortic ligament which keeps the aorta closely attached to the heart.

Reptilia

41. Placentation in *Hydrophis cyanocinctus* Daudin.

L. R. KASTURIRANGAN, Madras.

As a sequel to the author's paper, 'Placentation in *Enhydrina* schistosa (Daudin)', read before the 28th session of the Indian Science Congress, at Benares, *Hydrophis cyanocinctus* Daudin was investigated. It is shown that this species is also truly viviparous. The allantoic placenta is as highly specialized as in the case of *Enhydrina* but presents certain divergences which are worthy of note.

The placenta is formed by the modification of the uterine epithelium and the allantochorion. It includes two distinct regions. The general placental region differs from the corresponding region in *Enhydrina* in non-essential features only. It is characterized by the very superficial position of the maternal capillaries and the allantoic capillaries, the close approximation of which facilitates respiratory exchange. The special placental region (in both species) includes a glandular uterine epithelium and an allantochorion in which the deeper layers of the chorionic ectoderm are highly vacuolated and spongy in consistency. The function of this region seems to be nutritive. In *Hydrophis* this region varies in position. Its breadth is 7 to 10 mm. instead of 3·5 mm.; and the depth of the vacuolated chorion 20 to 30 microns instead of 80. The glandular cells of the uterine epithelium are less numerous. The two surfaces are smooth and without folds.

The paper includes also a discussion on the nutritive function of the placenta in reptiles.

42. The alimentary canal of the sea-snake *Enhydrina schistosa* (Daudin).

K. N. Parameswaran, Madras.

A ciliated epithelium lines the buccal cavity, pharynx and anterior region of oesophagus. The posterior oesophagus is devoid of cilia and goblet cells. The transition to the stomach is marked by the prominent folds of the glandular epithelium. The cardiac and fundic glands are identical in structure and staining reactions. The neck of the glands is composed of neck-chief cells which secrete mucus. The body is composed of only one kind of cell. These body cells, according to histo-chemical reactions, are seen to perform a double function—that of the parietal cell and body chief cell in mammals. The pyloric glands are exclusively mucus-producing.

Pyloric sphincter muscle and a pyloric valve are present. The coiled intestine is simple in structure without either glands or villi. The intestino-rectal valve is well developed. The general histology of the rectum is similar to that of the intestine. Other histological details are also given.

43. Some faunistic affinities and differences between India and Ceylon.

P. E. P. Deraniyagala, Colombo.

The faunistic similarity between Malabar and Ceylon is well known. Many animals common to the two differ subspecially, others form northern and southern subspecies with the dividing line at about 12° to 15° north latitude, while yet others persist unaltered. Interchange of animals during temporary land connexions appears to have been largely influenced by the prevailing climatic conditions which varied during periods of the Cenozoic era; associations of relict animals support such a view. Families doubtless proliferated both before as well as after isolation, during subsequent land reconnexion there was an interchange of new genera, e.g. the Uropeltidae. The time which elapsed since the entry of a genus into a country might be roughly ascertained by its range, but the various restricting factors should not be overlooked.

The faunas of both South India and Ceylon disclose a strong Malayan, a weaker African and certain Himalayan elements. Since these elements are seldom represented by the recurrence of the same species both in South India and Ceylon, a problem of special interest exists. One partial explanation might be that the faunistic routes to South India were always via peninsular India and that these invasions were followed by incipient extinctions in the north, whereas the entry into Ceylon was mainly by temporary southern routes; of interest in this connexion is the paralleling of Ceylon's living Malayan, African and North Indian faunal elements by part of the Islands' extinct fauna chief of which is the hippopotamus, an animal common in the areas mentioned and unknown from South India.

44. A preliminary account of the fauna of the mountain lakes beyond the Liddar valley, Kashmir.

G. MATTHAI, Lahore.

A study of the fauna of the high mountain lakes in Kashmir by a party of research workers from the Department of Zoology, Punjab University, Lahore, was commenced last summer when seven lakes in the region of the Liddar valley were visited, viz., (*a*) Shesh Nag, Sona Sar, Tar Sar, Chanda Sar, Dudh Nag, Sona Sar (Rewll) and Handil Sar. A preliminary account of the results obtained was read before the Section of Zoology at the last Session of the Indian Science Congress. In the summer of 1941, ten more lakes were visited, viz., (*b*) Tuliyan, Har Nag, Yam Sar, Khom Sar, Vishan Sar, Kishan Sar, Gad Sar, Gangabal, Kul and Nand Kol. These lakes, with the exception of Tuliyan, lie beyond the region of the Liddar valley.

The paper contains a general account of the faunistic work carried out in the ten lakes.

Cytology

45. On the cytology of the egg of a *Balanoglossid*.

(MISS) USHA SIRCAR, Lahore.

During his visit to Krusadai, South India, Dr. V. Nath fixed the ovaries of a *Balanoglossid* in Bouin, Champy and Da Fano. A study of the cytology of this egg was undertaken as there does not appear to be any previous account on the subject.

The ripe egg of *Balanoglossid* is about ·088 mm. in diameter. Two prominent inclusions can be seen in the cytoplasm, viz., albuminous yolk and the Golgi elements, the fatty yolk being conspicuous by its absence. The large vesicular nucleus of the egg contains a prominent nucleolus, but there are no nucleolar extrusions. The egg is surrounded by a thick structureless membrane which is pierced at one end by the micropylar funnel.

46. On the nuclear changes in the sperm of the fresh-water crab, *Paratelphusa* (*Paratelphusa*) *spinigera*.

(MISS) USHA SIRCAR, Lahore.

The genesis of the bizarre and non-flagellate sperm of *P. spinigera* was worked out by Nath (1932) who confined himself to the Golgi apparatus, mitochondria, centrosomal structures, acroblast and the prominent mitochondrial vesicle, but did not pay any attention to the nuclear changes. It was, therefore, thought desirable to work out the details of the nuclear changes from the spermatogonia up to the ripe sperm.

The spermatogonial chromosomes are too small and numerous, but counts can be made in the first meiotic divisions, when the homologous chromosomes conjugate parasynaptically. In the polar views of metaphase 1, 58 chromosomes have been counted, each chromosome representing a homologous pair.

Important changes taking place in the spermatid nucleus are also described in the paper.

47. Spermatogenesis of the diplopod, *Thyroglutus malayus* (Carl) (Myriapoda).

GANAPATI PARSHAD SHARMA, Lahore.

This work was commenced in June, 1940. The material was fixed in Flemming—without acetic and Bouin's, and sections were stained with ·5% Iron-haematoxylin.

The sperm is non-flagellate and atypical, lacking a tail and perforatorium. There is a nuclear cup into which fits a vesicle. The latter is formed in the cytoplasm and all the mitochondria and Golgi elements merge into it. The mouth of the nuclear cup is closed by a well-developed cytoplasmic plug. A single prominent ring-like centrosome lies at the bottom of the nuclear cup.

Spermatogonia and Spermatocytes have also been examined in detail. Large chromosomes and prominent spindles appear in the meiotic divisions.

48. Spermatogenesis of the cattle-tick, *Hyalomma aegyptium.*

GANAPATI PARSHAD SHARMA, Lahore.

This work was undertaken in April, 1941. Ticks were collected from cows in Lahore dairies.

Primary spermatocytes and early spermatids have peculiar thick striated limiting membranes round them, and both possess well-developed mitochondrial and Golgi material.

A study of spermateliosis has revealed the presence of two types of sperm, one normal eupyrene and another abnormal apyrene. Their nature and formation are discussed in the paper.

SECTION OF ENTOMOLOGY

President:—D. Mukerji, M.Sc.

1. Structure and function of the Phallic gland in the cockroach *Periplaneta americana*, Linn.

P. D. Gupta, Meerut.

A large gland of unknown structure and function present on the left side beneath the ampullae and the ejaculatory duct, is found in the male cockroaches. This has been called by different authors as Phallic gland, Conglobate gland, or even Prostate gland. It is about 8 mm. long and tapers posteriorly to open on a membrane between the lobes of the left phallomere.

The exact structure of the Phallic gland has been overlooked by even Snodgrass and Qadri. The gland is composed of a double series of long very much coiled tubular structures arranged along a median duct into which they open. The tubules are so compactly arranged and bound together by a common investment into a flattened elongated mass. In section the gland shows a number of tubules cut in all directions. Microscopic examination reveals that all the tubules and the median duct have a similar structure. Each tubule is internally lined by a chitinous intima probably secreted by the epithelial cells. The cell-boundaries are not clear; large, prominent and deeply staining nuclei are present. The epithelium is supported on a basement membrane surrounded by connective tissue. From each nucleus fine ductules can be traced to the lumen of the tubules. The function of the gland has been shown to secrete the outer layer of the wall of the spermatophore.

2. The structure and formation of spermatophore in the cockroach *Periplaneta americana*, Linn.

P. D. Gupta, Meerut.

The spermatophore is slightly bigger than a pin-head, and a freshly deposited one shows an irregular outline. Later on it becomes moulded into various processes, depressions, and elevations by the pressure of the various parts of female genitalia. Each spermatophore has a single conical internal vesicle, closed normally by a plug at the conical end. The vesicle contains spermatozoa mixed with some fluid which keeps them in proper condition even outside the body of the cockroach. The vesicle is enclosed in a thick wall made up of three layers. The inner layer is the thickest and shows a laminated appearance; the middle layer is fibrous and vacuolated, and the outer layer is the thinnest and structureless.

The first trace of the spermatophore is visible in the ejaculatory duct about twenty hours after the final moult, and it is completely formed by the sixth day. The vesicle is formed from the secretion of small accessory glands, while the inner layer of the wall can be traced from the secretion of large accessory glands and the middle layer can be seen to be secreted by the ejaculatory duct. The wall of the fully formed spermatophore within the ejaculatory duct consists of only two layers; the outer wall is formed later on when it is being attached to the spermathecal papilla. The outer layer has been shown to be formed from the secretion of the phallic gland.

3. Copulation and insemination in the cockroach *Periplaneta americana* Linn.

P. D. GUPTA, Meerut.

Copulating pairs were observed in the laboratory during March, April, and May between 8 p.m. and 2 a.m. Spermatic fluid is contained in a well-developed spermatophore which is the only means of transference of sperms.

This paper includes a precise detailed account of the mating habits of the cockroach. It has been shown that glandular secretion has no effect on sex-attraction. It is only the instinct and a fully formed spermatophore in a male that excites him. Females remain indifferent rather avoid males, and do not try to mount their back. A period of six days must elapse after the final moult, before the male and female cockroaches are ready to copulate. Males can copulate several times at intervals of six days but females less frequently.

Males and females remain with their posterior ends joined together and their heads away from each other till insemination is completed. The duration of copulation on an average is 1 hr. and 20 min., but the climax is reached after 1 hr. when the spermatophore is discharged. The exact function and working of each of the components of the male and female genitalia have been described in detail.

The spermatophore, on being discharged, is attached to the spermathecal papilla and is found to remain there for 21 hrs. Its ultimate fate is obscure. The plug of the spermatophoral vesicle is dissolved and the spermatic fluid is most probably sucked in by the spermatheca.

4. Morphological studies on adult Trichoptera.

P. J. DEORAS, New Delhi.

The paper gives a detailed comparative account of the morphology of the head and mouth parts of the order Trichoptera. The study is confined to the adults belonging to the following eight genera:—*Anabolia, Stenophyllax, Rhyacophila, Hydropsyche, Goera, Polycentropus, Leptoceros,* and *Mystacides*. The size and shape of the head, the structure of the antennae, the form of compound eyes, clypeus, labrum, mandible, maxilla, labium, hypopharynx and the haustellum have been studied on a comparative basis.

It has been found that regular series could be built from the most complicated to the simplest forms. It has further been observed that all the structures in the same insect do not show the same amount of evolution. This leads to the consideration of the fact the same species do not evolve synchronously, and that there seems to have been a differential intra-organic evolution in this order.

5. On the comparative anatomy of the digestive system of the various phases of the termite *Termes redemanni* Wasm., and general consideration of the biological importance of the digestive system.

S. RAYCHAUDHURI *and* D. MUKERJI, Calcutta.

In this paper the following salient features are discussed thoroughly:—

1. Structural and functional peculiarities of the mouth-parts of different phases of the termite, from larva to the queen.
2. Structural peculiarity of the malpighian tubules of the queen.
3. Difference in disposition of the salivary receptacle in the worker and soldier castes.
4. Peculiarity in structure and function of the gizzard of the various castes.

6. On structure, function and origin of exudate organs in the mature deälated queen of the common mound-building termite *Termes redemanni* Wasm., and their bearing on the postadult growth of the queen.

S. RAYCHAUDHURI *and* D. MUKERJI, Calcutta.

There exists a difference of opinion as to the structure, function and origin of exudate organs in the queen of termite *Termes redemanni* Wasm. Holmgren was of opinion that the tissue was a kind of gland present below the hypodermal layer of the bodywall and was composed of epithelial-like cells. Its secretions were assumed to pass to the exterior through hollow hairs or trichomes. Bugnion asserted that no hollow hairs could be found in the body of the queen. The authors in this paper have, therefore, investigated in detail the exudate glands and associated structure of the bodywall as the latter presents an exuding surface. They have also discussed the significance of the exudate organs in relation to social habit and their bearing on the physogastry of the queen. In that connection they have attempted to explain an aspect of the postadult growth of the female not touched by the previous authors. The authors' observations differ in many essential points from those of previous authors in the existence of secretory vesicles on the bodywall and direct communication of the exudate glands through tracheal-like ducts opening by separate apertures on the abdominal spiracles and also new formations of posterior abdominal spiracles in the queen.

7. Economic entomologists and nomenclatural acrobatics in systematic entomology.

T. V. RAMAKRISHNA AYYAR, Hyderabad-Deccan.

In this paper some of the difficulties experienced by economic entomologists in connection with the scientific names of the insects they have to deal with, are set forth and a suggestion made to minimize the difficulties. It is nowadays found that the scientific names of even some of the very well-known insects are often changed from one to another and in some cases the new names again revert to old ones. Some examples of such nomenclatural acrobatics and permutations and combinations going on at present are also pointed out in the paper. The author feels that while some methods are necessary in getting organisms properly named, it has to be realized that classification is only a means to an end and not an end in itself. The author has no quarrel with systematists since they may have their own reasons for these constant changes, but only feels that some provision may be made by which economic workers could go on their way without coming into contact with these nomenclatural cataclysms. He has suggested the proposal that a committee may be formed to periodically approve sets of common popular English names for some of the well-known insects, irrespective of their scientific labels, so that we can gradually get together a list which will guide economic workers without troubling themselves with the frequent changes in scientific names.

8. Origin of fresh locust cycle in north-west India.

HEM SINGH PRUTHI, New Delhi.

In spring and early summer of 1940, the locust population in all the permanent breeding areas in Baluchistan remained low. In the desert tracts of Sind-Rajputana, the density of population was similarly low up to May, 1940. Migrant locusts began to appear in Sind-Rajputana in June and with the approach of monsoon a concentrated breeding took place in areas receiving good rainfall. The indigenous population being further supplemented by the fresh arrivals, the population reached an upper gradient. A number of yellow locusts were seen in Bikaner State in July. In August and September concentrated oviposition took place over a wide tract and the resultant hoppers bore gregarious characters and the adults developing from them formed pink swarms in October. Similarly, in Tharparkar (Sind) gregarious breeding took place resulting in the formation of pink swarms. The swarms which originated in autumn of 1940 in Sind-Rajputana migrated towards Punjab, N.W.F.P., Sind, Baluchistan and U.P. Some swarms presumably migrated further west towards Iran, Oman, etc. Overwintering forms were traceable in Mekran, Jhalawan and Kachhi areas. In Sind-Rajputana the highest population of overwintering forms was noted in the Bikaner State. Highest spring breeding of 1941 was observed in Jhalawan and Kachhi areas. Except in Dasht-Gwadar area, the spring breeding in Mekran was low. In Kachhi area spring breeding occurred on an extensive scale and the resultant hoppers developed gregarious features. But due to energetic control work carried out under the direction of the Locust Warning Organization no incipient swarming took place in that area. In Bikaner area of Rajputana, however, spring breeding of 1940-41 was light. First of summer migration 1941 towards east was traceable in Sind-Rajputana in May, but the highest increase in locust population was effected in north-west India in June and July 1941 by series of two waves of locust incursions from west obviously extra-Indian in origin. These swarms spread over Rajputana, Sind, eastern Baluchistan, western Punjab, N.W.F.P., and western border of United Provinces. Intensive gregarious breeding occurred in Sind-Rajputana and Las-Bela on the wake of monsoon rainfall and gave rise to pink swarms by latter part of August 1941 which subsequently getting mixed up with mature yellow swarms, actively flew over several parts of north-western India and penetrated as far south as northern districts of Central Provinces. Oviposition by these swarms took place in several localities giving rise to an autumn generation.

9. Two major insect pests of the Deccan.

T. V. Ramakrishna Ayyar *and* T. K. Venkat Krishnan, Hyderabad-Deccan.

Among the different zoo-geographical regions into which India is generally divided, the Deccan plateau, lying between the Eastern and Western Ghats forms a very important and distinct area; and the greater part of this extensive table-land is included in the Indian State of Hyderabad. Though the fauna and flora of this tract are in many respects similar to those of the adjacent coastal plains and the Indo-gangetic alluvial areas, the peculiarities in the physical features and climate of the region are found to exercise a considerable degree of influence on the plants and animals inhabiting the region. It is therefore needless to add that a study of the flora and fauna of this important and practically unexplored region might add to our knowledge in the fields of Botany and Zoology in various directions. In view of the fact that we have hardly anything on record regarding the important insects of this area, an attempt is made in this brief paper to give some ideas of two of the most important insects of the tract with their life features and their economic importance to the area—especially to the Deccanese farmer.

It is found that in the extensive upland areas of this tract, ranging from 1,200 to 2,000 feet in elevation and with a scanty rainfall, the great majority of the cultivated plants are necessarily only dry crops; and among these, Millets (including Jowar and minor Millets), Cotton and Castor occupy very important and high rank. It may even be added that among these crops Millets and Castor are comparatively far more important to this particular area; this will be evident from the fact that the Hyderabad State has under Jowar an acreage of nearly nine million acres, far above any other province in India. And as regards Castor, the area under this crop in the Hyderabad State represents more than fifty per cent of the total area under Castor in the whole of India. Though there are other crops like Paddy, fruits and other miscellaneous ones with their respective insect enemies, the annual toll levied by the insect pests of Jowar and Castor in this area is found to be very substantial; and especially during unfavourable years similar to the present, the loss caused by noxious insects to these major crops becomes very appreciable. Among the different insects doing damage there are two insects which play a very important part in connection with these two crops. One is the Red Hairy caterpillar (*Amsacta albistriga* M.) which attacks almost all dry crops and the other the Castor Semi-looper caterpillar (*Achoea janata* L.) a serious pest affecting the Castor crop almost exclusively. A very brief summary is given in this paper on the bionomics, the economic importance of these two insects, and what is being done in this connection by the Agricultural Department of H.E.H. the Nizam's Government, especially during the current season. It is believed that this paper might attract the attention of other workers on similar insects in other parts of India and help to bring these workers into contact.

10. A short note on *Sinoxylon anale* Lesne, on mango plants in the Gwalior State.

C. B. L. Bhargava, Gwalior State.

Sinoxylon anale, a Bostrichid wood-borer, which is generally found to tunnel the dead trees, fresh cut logs and old, dry material did considerable damage to healthy and grown-up mango plants at Bhilsa, a district town of the Gwalior State, by boring into their stems and branches. The infection most probably came from bamboo sticks, which were used to prepare 'tutties' to protect young fruit plants against frost. Pest was active from December to May. Nature and mode of damage is described. In one of the galleries in association with *S. anale* adults of *Sinoxylon crassum* were also found.

11. The fecundity and longevity of *Earias fabia* Stoll and its parasite *Microbracon greenilefroyi* (D. and G.) under different conditions of temperature and humidity.

Taskhir Ahamad, New Delhi.

At a low temperature of 16°C., which is close to the threshold, the fecundity of both the host and parasite is reduced, but the reproductive potential of the host is only one-fourth that of the parasite. Thus, whereas the parasite can easily maintain itself at this temperature, the host cannot. This confirms our previous finding (*Indian J. Ent.*, *1*, 17–47) that contrary to common belief, low temperatures are more injurious to the host than to the parasite. The host possesses maximum reproductive power at 30°C. the parasite at 25°C. In regard to the upper vital limit, the host can lay a number of eggs at 35°C., while the parasite becomes completely sterile.

Between 25° and 30°C., which is the optimum range of temperature, the fecundity of the host is distinctly lowered if it is bred from material kept under saturated conditions, that of the parasites is reduced when they are reared from material under rather dry conditions (14 mm. S.D.). This supports the conclusion previously reported that moist conditions are generally more favourable to the parasite than to the host.

At 16°C., the longevity of parasite adults is more than double that of the host adults. Between 20° and 30°C. the adults of both live for about a fortnight or so. At 35°C., the host adults live for over 4 days while the parasite adults die within 2-3 days. Here again the less harmful effect of low temperature and more injurious influence of high temperature on the parasite as compared to the host are obvious.

Data on the incidence of *Earias* spp. and *Microbracon greenilefroyi* collected by weekly examination of cotton buds and bolls in the field were correlated with rainfall and temperature during 1939 and 1940. It was noticed that during May and June, the hottest and driest period of the year, the population of bollworm was fairly high while the parasite was extremely rare. With the first shower of monsoon rain in the end of June and consequent fall in temperature and rise in humidity the incidence of the parasite shot up and soon brought the pest under control.

12. Insect vectors of virus diseases. Experiments on the control of the white-fly vector and leaf-curl disease of tobacco.

HEM SINGH PRUTHI *and* C. K. SAMUEL, New Delhi.

In the last session of the Indian Science Congress (1941), it was shown on the basis of experimental work carried out at Pusa that tobacco virus has a wide host range; several alternate hosts of the virus are also food-plants of the white-fly vector, *Bemisia tabaci* (Gen.) (= *gossypiperda* M. and L.). Having carried out detailed investigations on the life- and seasonal-histories of the vector, its range of food-plants and its incidence in tobacco fields at different times of the year, some experiments were performed during the last tobacco season with a view to discover suitable methods of controlling the vector and leaf-curl disease. Nursery seedling of I.P. 142 were raised in August and September in a set of four seed-beds (each 8 ft. $\times$ 4½ ft.) treated as follows:—

One of the seed-beds was sprayed with nicotine sulphate, the second with fish-oil-rosin-soap, the third was covered under an insect-proof muslin cage, while the fourth one was left exposed to natural weather conditions. Four sprayings were thus given to the August-sown seed-beds, and three to the September-sown ones at 8–10 days' intervals. The corresponding control seedlings were raised under three sets of conditions, of which one set was exposed without any spray treatment, the second was exposed and sprayed with fish-oil-rosin-soap, while the third was kept covered under a muslin cage. The seedlings were transplanted when about 5 weeks old in three separate fields each having 36 randomized blocks.

Sprayings with the above insecticides were continued in two fields, the third acting as control. Weekly observations on the white-fly and leaf-curl incidence were recorded in all the blocks up to the middle of April 1941. The data obtained showed that the white-fly and the disease could be controlled better by commencing the spray in the seed-bed and continuing it in the field till the end of October, as tobacco is most susceptible to infection at the age of 8–10 weeks. Of the two insecticides, nicotine sulphate and fish-oil-rosin-soap, the latter gave better results.

Further transmission experiments revealed that 15 minutes' feeding on tobacco and 45 minutes' feeding on *Ageratum* was sufficient to enable the vector to transmit the disease to healthy tobacco. Also white-flies fed on diseased tobacco for 15 minutes were able to infect successively four healthy tobacco seedlings in 4 to 5 days, thus showing that they remained viruliferous almost throughout their life.

The seedlings protected under insect-proof covers in the nursery stage showed lower incidence of the white-fly and correspondingly lower incidence of the disease than those kept exposed.

Experiments have shown that tobacco virus is not transmissible through the seed.

One more new Chalcid parasite, *Prospaltella* sp., of the white-fly was noted for the first time.

13. Anopheles breeding in the rice fields.

P. Sen, Calcutta.

The paper deals with the nature of *Anopheles* breeding in the rain-fed rice fields of some Bengal villages. An elaborate study has been made of the successive changes in the anopheline fauna connected with the various stages of the rice cultivation, as also with the gradual increase in the height of the rice plants. The larval incidence of the various species of *Anopheles* at different depths of water in the rice fields has also been traced.

14. A survey of the Anopheline fauna of Izatnagar (Dist. Bareilly, U.P.).

B. C. Basu, Mukteswar.

A brief survey of the Anopheline fauna in relation to the prevalence of malaria at Izatnagar (District Bariolly, U.P.) was made in October 1940. Information is given with regard to topography and climatic conditions of the place.

Seven species of Anophelines were found breeding in various sites in the area. They were: *A. subpictus, A. barbirostris, A. hyrcanus* var. *nigerrimus, A. annularis, A. culicifacies, A. stephensi* and *A. fluviatilis.*

Two species of malaria parasites were prevalent in the locality, namely, *Plasmodium vivax* and *P. falciparum*—the latter being the predominating species.

Methods for control of the mosquitoes for the area are suggested.

15. Atmospheric temperature and humidity in relation to experimental transmission of malaria by *Anopheles annularis.*

B. C. Basu, Mukteswar.

The limits of atmospheric temperature and relative humidity between which the transmission of malaria by *Anopheles annularis* may take place were studied under experimental conditions. 14,952 laboratory-bred *A. annularis* were fed on 129 gametocyte-carriers of three Indian forms of *Plasmodia* (*P. vivax* 52; *P. falciparum* 62; *P. malariae* 15) and immediately after feeding they were put in Barrawd Cages and exposed to 36 different combinations of temperature and humidity in an air conditioning cabinet at which any combination of temperature between 50°F. and 100°F. and relative humidity between 5% and 100% could be adjusted. The surviving mosquitoes were dissected at different intervals and their guts and salivary glands examined for malarial infection. The findings made were as follows:—

(i) Temperature plays an important part in the transmission of malaria with *A. annularis.*

(ii) At 50°F. and all humidities between 50 and 100% no infection takes place with any species of malaria in *A. annularis.*

(iii) At 100°F. and all humidities between 50 and 100% no transmission of malaria with *A. annularis* is possible as the mosquitoes do not survive till they are infective.

(iv) Infection with both *P. falciparum* and *P. vivax* occurs at temperatures between 60°F. and 90°F. and humidities between 50 and 100%. Salivary infection is seen frequently.

(v) With *P. malariae* no salivary infection was observed. Heavy gut infections were observed at temperatures between 80°F. and 90°F. At 60°F. and 70°F. the number of experiments were very limited due to scarcity of quartan gametocyte-carriers.

16. Some interesting observations on a Sarcophagid fly.

P. J. DEORAS, New Delhi.

In his description of the species *Sarcophaga dux* Thom. var. *scorpariiformis* Senior-White, the author has mentioned that there are a number of forms of this species occurring everywhere except in the Neotropical region.

Some Sarcophagid flies of the same species were caught at Delhi and their life-history studied. Those flies larviposited naturally as well as in captivity. It has been possible in one case to get eggs from a specimen, while these flies are normally larviparous.

The maggots were fed on a variety of diet including manure, maggots, caterpillars, toads, snakes and 5% sucrose solution. Regarding the internal anatomy of the maggots, it appears that the pharyngeal skeleton and the spiracles of the younger maggots differ much from those of the fully grown ones. By feeding the maggots for a varying time and on a variety of diet, it has been possible to get adult flies of different forms, varying in size and colours. There are both male and female dark flies of the smaller size, yellow coloured flies of the medium size, and slate coloured flies of the big size. The fly of the smallest size lived the longest in the laboratory and larviposited parthenogenetically.

17. *Thevetia neriifolia* Juss—a source of an efficient insecticide.

M. C. CHERIAN *and* S. RAMACHANDRAN, Coimbatore.

The paper gives the results of spraying trials with kernels of *Thevetia neriifolia* Juss against pests of crops. Aqueous infusions of the kernels with addition of an equal quantity of soft soap were tried against insects and mites in different dilutions and found very effective. The optimum concentration for aphids (*Aphis malvae* K. and *A. tavaresi* D.), tingids (*Urentius echinus* D.) and the castor mite (*Tetranychus telarius* L.) appears to be ¼ oz. of the kernels in a gallon of water, while caterpillars like *Laphygma exigua* Hb., *Eupterote mollifera* W. and *Parasa lepida* G. require a strength of ½ oz. Coccids like *Pseudococcus virgatus* C. which have a mealy covering require stronger concentrations varying from 1 to 2 oz. per gallon. Apart from the use of the kernels as an effective insecticide, the plant is also useful as a cheap and quick-growing fence.

18. Studies on *Stomopteryx nerteria* Meyr—a pest of groundnut in Madras Presidency.

M. C. CHERIAN *and* MD. BASHEER, Coimbatore.

Stomopteryx nerteria is one of the important pests of groundnut in the Madras Presidency. The caterpillars feed on the leaves as a result of which the leaves get dried up. The pest was studied at the Agricultural Research Station, Tindivanam. The life-cycle of the insect varied from 15 to 28 days, the egg, larval and pupal periods being 3 to 4, 9 to 17 and 3 to 7 days respectively. The maximum number of eggs laid by a female was 473, the average for fourteen females being 185·8. The maximum longevity was 36 days; without food the moths did not live for more than 4 days. Data on the number of moths attracted to a Hurricane light from July 1939 to June 1941 are given; the maximum number was reached in September. Varieties of groundnut—spreading as well as bunch—were studied for pest resistance.

19. Bionomics and control of *Nephopteryx eugraphella* Rag, a Pyralid pest of Sapota.

M. C. Cherian *and* K. P. Anantanarayanan, Coimbatore.

The paper deals with the habits and life-history of a caterpillar pest on Sapota at Coimbatore. This Pyralid moth—*Nephopteryx eugraphella* Rag—has appeared in large numbers to form a serious pest since 1938. The caterpillar damages the leaves, flower buds and to some extent the ripe fruits also. The injury to the tree becomes obvious, by the presence of numerous twigs and shoots whose leaves and buds are dried up or webbed together with silken frass. The young larvae tunnel into buds while the young and older ones scrape and feed on leaf surface. More than half the number of shoots in a tree may be found badly affected in the course of two or three generations of the pest in the same tree. Data so far gathered on the life-history of the insect together with observations on the control of the pest are also presented.

20. Studies on *Platyedra gossypiella* Saunders, the pink bollworm of cotton in South India.

M. C. Cherian *and* V. Margabandhu, Coimbatore.

Studies on *Platyedra gossypiella* Saund., which forms one of the major pests of cotton in South India, were made with reference to its larval habits and its incidence among the different varieties of cotton.

A study of its larval habits was made by burying mature bolls of irrigated Cambodia at different depths and placing bolls over red and black soils and ordinary sand. Trials set up indicate that, when bolls are buried at 3″, 6″, 9″, 12″, 18″ and 24″: (1) the larvae come out in the case of all the depths including 24″; (2) they continue to emerge for about 20 days after burial, though the numbers dwindle after a fortnight; and (3) the largest number of larvae emerge from the 3″ pit. When infested bolls are kept over sand or any loose soil, about 50% of the larvae pupate within the bolls while the rest pupate either on the soil surface or in the first 1″ layer.

In stray instances larval diapause is in evidence. Thus, larvae collected during February and March 1941 underwent diapause with a duration of about four months. In two cases, larval diapause lasted for nearly six months.

A number of varieties of cotton—both irrigated and rain-fed—at the Cotton Breeding Station, Coimbatore, were examined for bollworm incidence and the results are indicated.

21. Notes on some insect parasites of economic importance in the Madras Presidency.

M. C. Cherian *and* M. S. Kylasam, Coimbatore.

The data collected in the course of the last decade on parasites bred from crop pests are presented in this paper. The insects included herein represent several families like Tachinidae, Braconidae, Ichneumonidae, Chalcidae, Bethylidae and Dryiniidae. Notes on their hosts, distribution and parasitic habits are mentioned wherever possible. Information on several new species is for the first time brought on record.

22. Preliminary observations on the biology and control of *Chilo zonellus* Swin.

Khan A. Rahman, Lyallpur.

Chilo zonellus S. is the most destructive pest of maize and 'Jowar' (*Andropogon sorghum*) in the Punjab.

Moths become active after dusk when they mate. The females lay eggs in clusters of 30–40 eggs each mainly on the underside of the leaves. Each female, on an average, lays 350 eggs. Egg-stage occupies 3–6 days. The caterpillar is recognizable by its dirty white body which is ornamented with four longitudinal brown stripes. The caterpillars are full fed in 16–31 days when they pupate, the pupal stage occupying 6–9 days.

The pest hibernates as a caterpillar in the stubbles of maize and 'Jowar' during the period from October to March. Moths from these overwintered larvae begin to appear on the wing in the third week of March, when damage begins. The pest remains active during March–October when it passes through 6-7 generations.

The most effective method to deal with this insect is to sow the maize crop for grain during 10th–20th August.

23. Biology of *Trogoderma khapra* Arr.

KHAN A. RAHMAN, Lyallpur.

Trogoderma khapra Arr. is the most destructive pest of stored wheat in India. In the Punjab it is present throughout the plains and submontane regions, being particularly serious in the canal colonies. Though wheat is its most favoured food, it also attacks 'jowar', maize, rice, barley and gram.

The eggs hatch in 3–5 days and the larval and pupal stages are completed in 18–28 and 2–4 days in males and 20–35 and 3–5 days in females, respectively. The females live for 5–14 days and lay 13–85 eggs in 2–5 days at the rate of 1–22 eggs per day.

The pest hibernates as larvae from October to March. They become active in the beginning of April, the adults emerging from them in the end of April or beginning of May. It passes through 4-5 generations in a year and does the greatest damage during July–September.

24. Cherry and apple tree borer (*Aeoleasthus holosericea* F.) in the Punjab.

KHAN A. RAHMAN, Lyallpur.

Introduction.—*Aeoleasthus holosericea* F. was first recorded at Dehra Dun in 1889 from Sal and *Terminalia tomentosa*. In the Punjab it was collected for the first time in 1936 damaging cherry and apple trees in the Kulu Valley. Subsequent field observations on it showed it to constitute a serious menace to the cultivation of cherry in the valley and therefore detailed investigations were made on it during the last three years with a view to study its bionomics and control. The results are presented in this paper.

Distribution and food-plants.—The cherry and apple tree borer is very widely distributed in India. In the Punjab it has so far been reported from the Kulu Valley, Kotgarh and Simla Hills. The pest feeds on cherry, apple, apricot, peach and their wild relations, walnut, mulberry, 'Kosh' (*Alnus nitidus*) and plum, but is primarily a pest of cherry and 'Kosh'.

Descriptions of various stages.—Eggs: Length 2·25 mm., breadth 1 mm., oval with a distinct thickened petiole.

Grub.—A full-grown grub measures 75 mm. in length and 13 mm. in breadth. Head small, triangular, antennae four-segmented. Prothorax larger than mesothorax. Abdominal segments with a series of small dorsal and ventral tubercles. Spiracle brownish colour.

Pupae.—Length 42 mm., breadth 35 mm. Second–seventh abdominal segments covered with numerous minute brownish spines. Last segment curved dorsally and produced into two tubercles.

Adult.—Length 32 mm., breadth 10 mm. It is a stoutly built beetle of a dark brown colour with a distinct iridescence. Its prothorax is wrinkled and furrowed and its elytra are furnished with shoulders at their proximo-lateral angles.

Life-history.—The females lay eggs singly usually in the injured areas on the bark; they are pushed into the plant tissue by means of the ovipositor. In confinement a female laid a maximum number of 92 eggs. The eggs take 7–12 days to hatch. The newly hatched grub feeds on the inner layers of the bark making shallow, narrow and zigzag galleries, but when older it feeds both on the inner layer of the bark and the outer layer of the sap wood and when full-grown it bores into the main wood through an elliptical hole which is later on used as an exit hole by the adult. The grub stage occupies from 27 to 32 months. It pupates in a specially constructed chamber the distal end of which is packed with calcarious deposit. The pupal stage occupies from 40 days to 100 days. The table below gives the duration of the life-cycle of the pest.

Statement showing the duration of life-cycle of Aeoleasthus holosericea F.

(For the sake of brevity only three cases are given.)

No.	Date of oviposition.	Date of hatching.	Duration of egg stage (in days).	Date when grub stopped feeding.	Date of pupation.	Date of emergence of beetle.	Duration of resting stage (in days).
1	15-9-38	24-9-38	9	27-11-40	15-4-41	2-5-41	4–19
2	4-10-38	16-10-38	12	2-12-40	15-4-41	30-5-41	4–13
3	14-10-38	26-10-38	12	2-12-40	15-4-41	2-6-41	4–13

Seasonal history.—The annual calendar of activities of this pest is tabulated below.

Month.	*Stage of Aeoleasthus holosericea.*
April ..	.. One and two years old grubs, pupae; resting beetles start emerging by the end of this month.
May–July	.. All stages found.
August-September	.. Beetles, eggs and grubs present.
October ..	.. Beetles rare, egg and grub present.
November	.. Grubs present, old grubs start resting.
December	.. Young beetles and young and resting grubs present.
March ..	.. Active and resting grubs and resting beetles present.

Damage.—The adults do not do appreciable damage. The grubs are the real culprits, for if no control measures are adopted they kill the attacked plant.

Control.—Various chemicals, etc., were tried to find out the one which will control the pest effectively. Kerosene oil has so far given the best results against the grubs.

25. Trials with various chemical dusts against pests of stored wheat in the Punjab.

KHAN A. RAHMAN, G. S. SOHI, *and* A. N. SAPRA, Lyallpur.

Copper carbonate, sodium fluosilicate, Katelsousse, tobacco dust, borax and sulphur were tried in varying doses to protect 400 grams of wheat in small earthen jars from *Trogoderma khapra* Arr. In each jar as many as 300 grubs of this pest were introduced. Copper carbonate (0·5%) and sodium fluosilicate (1·0%) proved very effective and quick acting. Katelsousse (2·0%), tobacco dust (2 and 4%) and borax (1·0%), on the other hand, though effective were comparatively slow acting thereby allowing certain amount of damage by the insect. Sulphur, however, did not prove effective. In treated samples the percentage of attack was 0·28%, 0·1%, 4·4% 8·9%, 8·0% and 60·7% in case of copper carbonate, sodium fluosilicate, Katelsousse, tobacco dust, borax and sulphur respectively as against 100% in the control lot. None of the dusts, excepting sodium fluosilicate which reduced it by 43% affected the germination of seed.

Copper carbonate and Katelsousse in 0·3% and 1·5% doses respectively proved equally effective against *Calandra oryzae* L.

26. Biology of *Adoretus pallens* Blanch (Rutelidae: Coleoptera).

KHAN A. RAHMAN *and* M. A. GHANI, Lyallpur.

Adoretus species are serious pests of fruit trees in the Punjab. They either eat holes in the leaves or skeletonize them. Of these *A. pallens* Bl. is the commonest and most destructive in our province.

A. pallens Bl. is widely distributed in the Punjab. Though a general feeder it shows special preference for 'ber' plants.

The adults are nocturnal in habit; they mate and feed after dusk and spend the day in hiding in the upper 3″ of the soil.

Eggs are laid singly in cool and moist soil; a maximum number of 80 eggs was deposited by a female in the laboratory. Incubation period varies from 6–9 days. The larvae are full-fed in about 1½ months, when they stop feeding and construct a cocoon of soil particles for hibernation.

Pupation takes place in April, in their hibernating cells and lasts for 11–13 days.

The pest is active from May to August when all its stages are present. It hibernates as a grub during winter, the adults from these overwintered larvae appearing on the wing in May.

27. Black citrus fly (*Aleurocanthis woglumi* Ash.) and its control.

KHAN A. RAHMAN *and* DINA NATH TANDON, Lyallpur.

Black citrus fly is one of the most destructive of citrus pests in the Punjab. It is widely distributed in our province and has so far been reported to be seriously destructive from Lahore, Montgomery, Muzaffargarh, Multan, Hissar and Kangra. Of the various species of citrus on which it feeds it prefers orange and malta trees.

The eggs are elongate oval and are laid on the underside of leaves in a spiral form. They are pale yellow when freshly laid, but change to orange brown before hatching. The nymphs are black in colour and scale-like in appearance, and the adults are dark-brown with smoky wings, their bodies being covered with white waxy powder.

Of the various insecticides tried against the eggs, nymphs, pupae and the adults of this pest, rosin compound in the strength of 1 : 5 killed cent per cent of the adults. The best time to apply this insecticide was found to be September when the adults congregated in large numbers on the tender leaves for mating and egg-laying.

28. Bionomics and control of sugarcane stem borer (*Argyria sticticraspis* Hmps.).

KHAN A. RAHMAN *and* DALBIR SINGH, Lyallpur.

Sugarcane stem borer (*Argyria sticticraspis* Hmps.) is the commonest and one of the most destructive of sugarcane pests in the Punjab: in the arid and drier parts of the province it may destroy up to 72% of young sugarcane during April–June.

Moths are nocturnal in habit and live for 2–4 days.

A single female can lay 429 eggs in three days. The life-cycle of the pest is completed in 27–47 days as follows: egg stage, 5–11 days; larval stage, 15–23 days; pupal stage, 7–13 days. It hibernates as a larva in the stubbles of sugarcane.

The pest remains active during March–October. It does not attack all sugarcane varieties with equal severity. It kills the main shoots thereby reducing the yield of the crop considerably: the juice from attacked sugarcane has lower purity coefficient and deteriorates rapidly.

The 'borer-stabbing' method of controlling this pest together with 'sanitary fluid treatment' and removal of affected shoots was tried and it was found that by the first method (1) 95·9% of the larvae were killed, (2) no buds were damaged, and (3) least time was required to treat an acre with 4,000 affected shoots.

29. Further studies on the biology of the giant mealy bug *Drosicha stebbingi* Gr.

KHAN A. RAHMAN *and* ABDUL LATIF, Lyallpur.

The eggs begin to hatch (after eight months) in the second or third week of January, all of them hatching in 25–55 days, at Lyallpur. The female passes through three and the male through four, instars, which are completed in 76–138 days as follows: first instar, 45–71 days; second instar, 17–38 days; female third instar, 15–26 days; pre-pupal or male third instar, 5–10 days. The pupal stage occupies 9–15 days.

The females start laying eggs in the second week of May and continue to do so till the end of June.

30. Biology of the woolly bear (*Anthrenus vorax* Waterhouse).

KHAN A. RAHMAN *and* G. S. SOHI, Lyallpur.

Anthrenus vorax Waterhouse, commonly known as 'the Woolly bear', is very widely distributed in India. In the Punjab, as elsewhere, it destroys woollen articles, boot polishing brushes, stuffed birds, hoofs, bones, etc.

Descriptions of its various stages are given and its life-history is described in detail. Copulation takes place immediately after emergence and 2–7 days after copulation the female lays 11–52 eggs in 1–8 days at the rate of 3–25 eggs per day. The eggs hatch in 7–14 days and the larval and pupal stages occupy 223–465 and 9–28 days respectively. The entire life-cycle is thus completed in 239–507 days. The pest remains active during March–October.

The adults of this pest visit flowers. The larvae are carnivorous (they feed on their own pupae) and negatively heliotropic.

31. Variations in tongue length of the honey-bee.

KHAN A. RAHMAN *and* SARDAR SINGH, Lyallpur.

Studies in the variation of the external physical characters of the honey-bee *Apis indica* F. were taken up at the Government Bee Farm, Katrain (Kulu Valley, Punjab) in 1940. The present paper deals with the tongue length of the Katrain variety of *Apis indica* F. The tongue lengths of 100 bees, each from ten colonies at the Bee Farm, were measured and it was found that the Katrain bee has a tongue length of 5·525 mm. Tongue lengths of *Apis florea* and *Apis dorsata* from Lyallpur, in each case 100 specimens, were also measured and their mean lengths were found to be 3·441 mm. and 6·683 mm. respectively.

Tongue lengths of the honey-bees from different parts of the world as worked out by other research workers are also given for ready reference.

32. Brinjal stem borer (*Euzophera perticella* Rag.).

SYED A. SHAH, Lyallpur.

The moths appear on the wing towards the end of March. Two to four hours after mating the females lay eggs singly or in batches usually in the angles formed by the veins with the mid-rib. During the period from April to mid-October all stages of the pest are present in the fields.

Its life-cycle, depending upon the prevailing climatic conditions, is completed as follows:—

Egg stage	..	..	..	3–10 days.
Larval stage	..	..	..	26–58 „
Pupal stage	..	..	..	9–16 „

Brinjal stem borer is a serious pest of brinjal seedlings in the nursery and young plants in the fields. To control it: (1) ratooning of brinjal should be avoided (2) dry brinjal plants should be burnt as soon after uprooting them as possible, and (3) attacked plants in the nursery and in the fields should be destroyed.

33. Biology of *Indarbela* sp.

ZIA-UD-DIN, Lahore.

The present paper deals with the life-history of a species of *Indarbela*, the larvae of which are commonly known as bark-eating borers. Nine instars have been recorded in the annual life-cycle. Another interesting fact is that the imago lays eggs in strings which are beaded in appearance.

The author has discussed in detail the ecology of the pest, and has suggested remedial measures for the extermination of the pest.

This pest is doing considerable damage to *Albizzia procera*, citrus, mango and Aonla trees in the Punjab.

34. On the longevity of *A. culicifacies* under controlled conditions of temperature and humidity.

RAJINDER PAL, Lahore.

Preliminary observations were recorded on the longevity of *A. culicifacies* in a paper communicated last year. The work has now been completed.

It has been possible to study the effect of temperature ranging from 50°C. (122°F.) to −2°C. (28·4°F.) in combination with varying humidities.

It is concluded that at temperatures from 25°C. (77°F.) to 30°C. (86°F.), with humidity ranging from 60 to 80%, this species can survive from 15–28 days and thus can prove very dangerous. Such conditions are also favourable for the development of the malarial parasites.

Evidence on the longevity of *A. culicifacies* based on field investigations is also incorporated.

35. Biology of a new Ichneumonid parasite of the Amaranthus stem weevil in South India.

P. N. KRISHNA AYYAR, Coimbatore.

In exploring the possibilities of biological control of the cotton stem weevil of South India, some attention was directed towards the study of the biology and natural enemies of allied curculionids of similar habits. Among such forms, the common Amaranthus weevil of South India, *Hypolixus truncatulus* F., proved to be the most useful laboratory host for many species of parasites. An account of this weevil and its parasites was presented before a previous session of this Congress (Calcutta, 1938).

Since then the studies have been continued, though intermittently, and a few new and interesting species of parasites have been encountered. One such species forms the subject of this short paper. The parasite in question is a new species of Ichneumonid belonging to the genus *Xoridescopus*. An account of this parasite together with its life-history and habits is furnished.

It is a primary ectophagous larval parasite of *Hypolixus truncatulus* F. preferring the late third and fourth instars of the host grubs for parasitization. It has a few other hosts which are all stem-boring weevils. The parasite stings and completely paralyzes the host before oviposition with a maximum capacity of 34 eggs per fertilized female in captivity. On account of intense larval fight, never more than one larva was seen to survive beyond the first stage on a single host. The total life-cycle covered an average of 27 days made up of an egg period of about 30 hours, larval period of 8·4 days, a pre-pupal period of 4 days and a pupal period of 13·7 days. The length of life of adults never exceeded 67 days. Detailed descriptions of the immature stages, the development of cephalic skeleton and mouth parts and the pre-pupal phases have been presented since these form the most characteristic and distinguishing features of the species.

SECTION OF ANTHROPOLOGY

President:—M. H. Krishna, M.A., D.Litt. (Lond.)

1. Relation between cranial capacity and jaw-volume in South Indians.

A. Ananthanarayana Ayer, Madras.

There has been a progressive increase of brain size in relation to body size during evolution. The ratio between brain weight and body weight is the simplest method for comparison. Dubois' cephalization coefficient is considered to be a more accurate evaluation of the part of the brain which subserves intelligence and the coefficient of cephalization has also been used for comparison between different animal species and even different races of men. Weidenreich (1936) in his study of Sinanthropus has devised a relation between Cranial Capacity and Jaw-volume. It is a ratio between the intelligence apparatus and the masticatory apparatus and is based on the principle that the Cranium and Jaw have an inverse proportion to each other. The Jaw-volume is computed by multiplying the anthropometric measurements of, (i) length of mandible, (ii) bicondylar breadth, and (iii) height (length) of ramus of mandible. The chief advantages of this relation between Cranial Capacity and Jaw-volume are the use of minimum material and the possibility of using it even for fossil material where body weight cannot be known. Sixteen male adult South Indian skulls have now been investigated and the average value for the relation of Cranial Capacity and Jaw-volume is +2·7 and the value usually ranges between +2·4 and +3·0.

2. The somatometry of the Chinese of Calcutta.

M. N. Basu, Calcutta.

Somatometric measurements and somatoscopic observations were taken on 50 adult male Chinese of Calcutta. They are compared with the Chinese of Shantung, Manchuria, Chilhi and China proper. On analysis it is seen that the Chinese of Calcutta are composed of different anthropological types, the ethnical origin of which is more confused.

3. Blood groups of criminal tribes.

D. N. Majumdar, Lucknow.

There are in the United Provinces forty-six criminal tribes with a membership of nearly fourteen lacs. This does not include the mixed criminal gangs about forty in number, belonging to various castes and communities in the Province. Little data exist on the somatology and blood groups of these tribes. An anthropological survey of the racial elements in the population of the U.P. under the auspices of the Census of the Province, 1941, has been undertaken by the author which is expected to provide some very useful data on the criminal tribes. Malone and Lahiri have given the blood group data of a large number of people in the U.P., but as they do not give separate analysis for the social groups, castes or tribes, they do not tell much. Recently Dr. Macfarlane has given the blood groups of 43 Banjaras (*J.R.A.S.B.*, Vol. VI, 1940, No. I). In the present paper blood group data from two other criminal tribes are given and the author attempts to explain and interpret the group concentrations and their gene frequencies.

4. Studies of the whorl on head hair of the inmates of the Alipur Reformatory and Industrial Schools.

P. C. Biswas, Calcutta.

Within the hair on the head above the junction of two parieto-occipital sutures a single or more whorls may occur. The hair abruptly changes the usual course and forms spirals. I have examined one hundred juvenile delinquents of the Alipur Reformatory and Industrial Schools, Calcutta. Among those hundred data I have got 94% single whorl and 6% double, among these 94% single whorl there are 25% anti-clockwise and 69% clockwise. In comparing with the normal individuals it could be seen that there is some difference in the appearance of double whorls on the criminal head-hair. Double whorl appears in 17·5% in the normal whereas on the criminal head I have got 6%. Besides these in the normal head-hair three types of double whorl appear:—

1. Clockwise–anti-clockwise,
2. Clockwise–clockwise,
3. Anti-clockwise–anti-clockwise,

but among criminals I have got only one type, clockwise–anti-clockwise.

5. The use of the seals of Mohenjo-Daro.

C. R. Roy, Karachi.

A large number of seals with pictographic script and animal designs have been found at Mohenjo-Daro. Neither has the script been deciphered nor has the actual use of the seals been known. Here an attempt has been made to throw some light on the use of the seals. Some theories advanced: (1) they were connected with currency, (2) they were used to seal the articles of merchandise, (3) they were used as amulets. Drawbacks of these theories. Analysis and classification of the seals. Seals with the Unicorn have been found in large numbers and come from each and every house in Mohenjo-Daro. The Unicorn seal was universally used by people of the Indus Valley. Probable uses for the universal seal: (1) they may be connected with currency, (2) national dress and badge, (3) religion. Arguments against the first two theories. Only possible theory is that they were connected with religion. Sir John Marshall's cult of Mother Goddess and Shiva is partially correct. The principal religion was connected with the cult of the Unicorn. Clay sealings were used for the worship of a deity, the vehicle of which is the Unicorn. Votive sealings were in use from time immemorial and even at present the practices of sealings are found in the rites among the Vaishnavites.

6. Prehistoric tree-cult.

Nanimadhab Chaudhuri, Calcutta.

In the present investigation an attempt is made to trace the history of the cult of the fig tree, more particularly, of the pipal in India.

Besides the pipal leaf and branch which appear as decorative motifs on painted pottery unearthed in the Indus Valley and Baluchistan there have been found sealings with the whole pipal tree, with clear indications of the sacred import of the representation, and seals representing the tree-deity in anthropomorphic form in close contact with the tree have also been found. Coming to the Vedic age it is found that the pipal, udumbara and also nyagrodha are regarded as givers of fertility, wealth, cure, etc., and associated with the spirits of dead ancestors and other spirits. The Sūtras attribute also a malignant aspect of them. In the Mahabharata the banyan and udumbara retain their evil influence though they are also abodes of deities like the pipal. In the Puranas the pipal and udumbara promote conception, the banyan is an abode of pretas. In the existing orthodox worship, the pipal gives male children, wealth, etc., the udumbara cures disease. Elaborate ceremonies for planting the pipal for obtaining male offspring and for marrying it with the plantain tree are prescribed. In folk-worship, the pipal and banyan are worshipped for long life, wealth, male offspring and become a medium for transference of disease and evil. The pipal maintains its connection with ancestor-worship. In the Buddhist religion the pipal is worshipped for its association with the attainment of Buddha-hood by the Master.

The history of the cult shows that from the Atharva-Veda downwards the fig has been associated without a break with similar ideas. Perhaps the same ideas were also associated with the pre-historic cult of the pipal, because it seems, as Hutton has suggested, that the cult was originally a contribution of the earliest Negrito population of India being associated with fertility cults and ancestor-worship from a very early date, taken up from the successors of the Negritos by the Indus Valley people and developed by them. This indigenous cult was adopted by the Vedic Aryans and absorbed into their official religion, without the old associations of the cult being suppressed.

7. The goddess of child-birth.

NANIMADHAB CHAUDHURI, Calcutta.

In the present investigation an attempt has been made to show that an unanimity prevails in the worship of Ṣaṣṭhī, the goddess of child-birth and the guardian deity of childhood, in different provinces in India among Hindus and Hinduized tribes such as is not to be found in the case of any other functional deity; that though her popularity is so great, her cult has no existence in the Vedic literature, in the epics and in the earlier Puranas, proving thereby that she is probably a folk deity; that the cult has affiliations, on the contrary, with old cults of demonesses or female evil spirits killing germs and embryos, destroying children by causing them maladies and other ills, to be found in the Vedic literature, in the epics, in the Buddhist literature, etc.; that the existing worship of the goddess shows that protection from the malign influences of noxious spirits forms the most important element in it and that there are certain instances of folk-worship, probably of tribal origin, of vegetal deities such as Rūpesvarī, Burī, Gunri Thākurāṇī, Vana-Durgā, etc., offered by women for the protection and welfare of their children, which may appropriately be brought into connection with the cult of Ṣaṣṭhī.

From these considerations it is concluded that Ṣaṣṭhī the popular goddess of child-birth and guardian deity of childhood worshipped throughout India under such names as Chhathi, Satvai, Sathoi, Sathi, etc., was originally probably none other than an old child-destroying demoness with tribal affiliations who was transformed into a protectress of children like Hārīti, Jyeṣṭhā, etc., and next into the presiding deity of childhood. It is shown further that in this capacity, following a well-observed tendency, she has been identified with the great Devi as the mother of the universe, nurse of mankind, creatrix of the world, protectress of the gods, etc., and has acquired as a result thereof new attributes such as the giver of offspring, healer of barrenness, etc.

8. Kinship in the Vedic period.

K. P. CHATTOPADHYAY, Calcutta.

In this paper the writer discusses the papers on Vedic kinship terminology and usage by Dr. Irawati Karve published in the Annals of the Bhandarkar Oriental Research Institute. He points out that there is no evidence of a Vedic consanguinous family nor of marriage being the privilege of only the eldest son in the family. The term *devara* is shown to be used for any brother of the husband and not the younger brothers only as alleged by Dr. Karve. The parallel drawn between the Vedic family and the Khasa polyandrous family of Jaunsar-Bawar is also shown to be based on wrong identification.

9. Levirate in Assam.

J. K. Bose, Calcutta.

Levirate is the custom of marrying a deceased brother's widow. This institution is widely spread among the tribes in Assam. In this paper an attempt will be made to discuss the different types of levirate found amongst the tribes in Assam and a suggestion will be made as to the probable origin of this institution.

10. Some practical suggestions for the improvement of a primitive tribe.

Tarak Chandra Das, Calcutta.

The author of this paper at first evaluates the suggestion of some anthropologists about keeping the primitive tribes of India in so-called 'National Parks' where they will remain unaffected by outside influences. He next considers the Cochin State Scheme for the improvement of the Nayadis by settling them in State colonies where they are given land, houses, clothes and education, besides other amenities of life, free of any charge.

The author next puts forward his own suggestions for the improvement of a particular tribe, the Purums, living on the eastern border of India, which may be applied to other tribes as well, with slight modifications. Improvement is urgent in two spheres, namely, (a) health and sanitation, and (b) material comforts of life. In the opinion of the author, attempts at the spiritual uplift of tribal people are beset with many difficulties and should not be imposed from outside.

Ignorance of the rules of personal and domestic hygiene as well as rural sanitation coupled with the absence of any idea about the efficacy of scientifically prepared drugs is at the root of the high death-rate among the primitive people. This ignorance is to be removed and medicines made easily available. The author suggests means to attain this end.

To improve the material comforts of life more food, more leisure and more amusements are necessary. The author suggests the following measures for the improvement of the material condition of the Purums, namely, (a) introduction of a type of cotton for cultivation in the *Jhums* which may be used in the textile mills, (b) introduction of new food-crops, (c) encouragement of fruit-gardening, and (d) introduction of milk as a common food and rearing of cows and buffaloes. This would automatically give them more leisure which can be easily devoted to amusements. Production of art objects as a source of individual and communal pleasure should be encouraged. The monotony of their life may be relieved by introducing dramatic performances composed out of tribal myths. These may also be utilized to inculcate tribal morality.

But these attempts at improvement will largely depend on previous training for their success and the author sketches the type of education to be imparted to this primitive group together with the machinery for implementing this education which is expected to solve the difficulties of their life.

11. Some Munda religious ceremonies and their system of reckoning time.

M. B. Bhaduri, Dharanjaigarh (Udaipur).

1 & 2. Munda division of the year into three seasons—the stars presiding over the seasons. Natural signs and phenomena indicating

the seasons. Nirbisi explained. Religious ceremonies of the summer season.

3, 4 & 5. Religious ceremonies of the rainy season. 'Adra' explained. 'Sohrai' explained.

6. Religious ceremonies of the cold season.

7 & 8. Munda division of time into months. The system of naming of the months. 'Buru' explained.

9. Gola—Mage—end of the Mundari Year.

10. Umbra and eclipse of the Moon. Myth connected therewith.

11. Birhor eclipse myth.

12. Idea of eternity. Past, present and future.

13 & 14. Division of the month into days. Hours of the day.

15. Auspiciousness of the months.

12. A preliminary note on the typology of palaeolithic sites in Mayurbhanj.

D. SEN, Calcutta.

In this paper, the author discusses the typology of the newly discovered palaeolithic sites in the Mayurbhanj State. He has attempted to classify the main tool families with type tools and sub-types that make up the various industries. The tools in their typology seem to reveal the existence in the country of a phase or phases of an early palaeolithic civilization with core tool cultures somewhat recalling the abbevillian-acheulian of Madras but having peculiarities of their own. Different types of hand-axes, cleavers, choppers, discoids, scrapers, borers and other tools on cores characterize the lithic cultures. Besides the core tool series, there are pebble tools and also a very small number of flake-tools, and though they may form minor industries as such, their presence is significant. All the implements occur *in situ* in geologically datable lateritic deposits near Kuliana ten miles north of the Baripada town.

13. A study on pottery-making in a potters' village in Mayurbhanj.

D. SEN, Calcutta.

The whole process of pottery-making in the village has been observed and described in detail by the writer from the beginning to the end. How clay is brought from the khadan and prepared (in four stages) for the wheel—the required shape on the wheel, then how it is softly beaten to proper thickness and form, the process consisting of four stages and then the drying in the shade and lastly the preparing for and the firing in the furnace (poan) have been described in detail. The potter's wheel, the different instruments and the furnace are fully described. Pottery types, market and income, supplementary occupations, ceremonials, etc., are also given.

SECTION OF MEDICAL AND VETERINARY RESEARCH

President :—DR. C. G. PANDIT, M.B.B.S., PH.D., D.P.H., D.T.M., F.N.I.

1. Post-mortem bone marrow studies of kala-azar in man.

H. N. CHATTERJEE, Calcutta.

1. A case of acute kala-azar is described and the bone marrow changes depicted.
2. Different proliferative and degenerative changes in the subacute and chronic stages are depicted and their relation to the morphological changes found in the peripheral blood described.

2. Concentrated saline in the treatment of cholera. (A preliminary report.)

D. N. BANERJEE, Calcutta.

The material so far obtained from administration of concentrated sodium chloride solution in five cholera patients with high specific gravity of blood and collapse, and a few more with pulmonary oedema, supplies very encouraging result. A quantity of 50 c.c. of a 20% NaCl solution intravenously is quite sufficient to effectively lower the specific gravity of blood in a short time and serves the same purpose as that of three pints of hypertonic saline administered intravenously. The idea of this form of treatment has been obtained from the writer's observation that hypochloraemia is a prominent finding in cholera and that persists even after intravenous administration of saline suggesting that in cholera there is more loss of salts than of fluids.

The effect after administration of concentrated saline appears to be due to drawing in of the interstitial fluid into the circulation which exists in normal condition in a proportion of 3 to 1, i.e., interstitial fluid constituting 15% of the total body weight while the blood fluid 5% of the body weight. The most severe case of cholera shows a rise of 54% in the concentration of blood. Assuming that even when half of the total blood volume is lost, which is rather quite unusual, and that along with a considerable loss of interstitial fluid, it may be further assumed that a great amount of reserve in the interstitial fluid still exists which can be drawn into the blood in order to lower the specific gravity. The only drawback in the use of concentrated saline is the intense headache appearing immediately with the injection and lasting for some time. A few experiments have been performed on animals, which consist of 20 guinea-pigs injected intraperitoneally, 4 guinea-pigs subcutaneously, 5 cats intravenously with 20% and 10% NaCl solution to determine the lethal dose and other pharmacological effects of concentrated saline. Further animal experiments are in progress and those with concentrated saline with or without glucose and other chemicals and also administration of atropin, pituitrin, adrenalin, etc. These experiments are being done with a view to gain more knowledge before this method of treatment could be efficiently taken in hand during the next epidemic.

3. A study of the post-mortem femoral bone marrow of epidemic dropsy.

H. N. CHATTERJEE, Calcutta.

The essential features of the bone marrow of epidemic dropsy are:—

1. Oedema.
2. Dilatation of capillaries.
3. Leucoblastic reaction varying degrees.

4. Prophylactic vaccines. (Its application in the prevention of epidemics in India.) (*a*) Cholera vaccine.

A. K. SEN *and* A. K. HAZRA, Calcutta.

(1) Prophylactic vaccination:—

(*a*) Historical.

(*b*) Immunological problems.

(*c*) Modes of preparation of vaccines:

(i) Selection of strains.

(ii) Standardization.

(*d*) Application.

(2) Plea for a scientific application of mass immunization:—

(*a*) Forecast of epidemics.

(*b*) Survey of epidemic and endemic centres.

(*c*) Subsidiary prophylactic measures:

(i) Economic condition.

(ii) General sanitation (water-supply).

(3) Plea for co-ordination and co-operation amongst laboratory workers, field workers and clinicians for tackling this urgent national problem.

(4) Concluding remarks.

5. Dilution in the practical application of the precipitin reaction.

C. O. KARUNAKARAN, Trivandrum.

The practical application of the precipitin test serves two distinct purposes: (1) quantitative estimation, and (2) qualitative examination. In the first group, by noting the optimal condition in which a known amount of antigen or antibody reacts with varying amounts of unknown antiserum or antigen, it is possible to estimate fairly accurately its antibody or antigenic content. Here the antigen and the antibody are rapidly and gently mixed together so that the resulting reaction involves the entire antigen-antibody mixture. Dilution is no bar to the proper performance of this test. On the other hand, it is essential for the exact determination of the optimal point and helps in the rapid admixture of the antigen and the antibody. The quantitative relationship between the antigen and antibody dilutions has been worked out very carefully in this type of precipitin reaction.

In the second group known antisera are used for the qualitative identification of unknown antigens. Here is a pucca ring test in which the reaction is limited to the surface of contact between the two reacting substances or a slightly modified form of it in which, although the reaction is of a more diffused character, care is taken to prevent admixture of the two reagents except at the surface of contact. These tests are being done chiefly for the exact identification of unknown blood stains in medico-legal work and for determining the food preferences of mosquitoes in antimalarial work. If the ring formation is to be sharply defined, diffusion at the line of contact must be retarded as far as possible. Dilution of the antiserum would, therefore, appear contra-indicated in these tests. But antisera are diluted by many workers engaged in doing the ring test for one or two different purposes. (1) As a method for economy in the use of the antisera and to postpone the development of the ring to a particular time so that the readings can conveniently be taken after performing a large number of tests. Here a diluting fluid having the same specific gravity as the serum is used to prevent diffusion. (2) Antisera are diluted by persons engaged in medico-legal work to prevent the development of non-specific reactions within the time fixed for taking readings. But the effect of dilution of the antigen and the antibody on the formation of the ring does not seem to have received much attention.

The writer after experiments with different lots of anti-human and anti-bovine sera have noted the following:—

(1) In dilutions of the antigen over 1 in 1,000, the time taken by an undiluted antiserum for the formation of the ring bears a fair parallel to the degree of dilution.

(2) The potency of the antiserum can, therefore, be fairly accurately expressed by the time taken for the development of the reaction with 1 in 1,000 dilution of the corresponding antigen. This is helpful, particularly in view of the fact that a time-limit of 2 to 5 minutes appears to have been accepted by many workers for finding the highest dilution of the antigen with which the undiluted antiserum reacts.

(3) Dilution of the antisera using constant or varying dilution of the antigen shows that the time for the development of the reaction depends mainly on the diluent used. (*a*) If a homologous serum is used as a diluent, the time taken is found to vary with the degree of dilution. (*b*) With the diluting fluid recommended by Barber the time taken is out of proportion to the degree of dilution. (*c*) The effect of dilution with a heterogenous serum is intermediate between the diluting fluid and the homologous serum.

(4) The addition of carbolic acid in the diluting fluid does not have any influence on the comparatively poorer results obtained with it because the use of the diluting fluid without carbolic acid has given the same result and the addition of carbolic acid to the homologous serum used as diluent has caused no fall in potency.

(5) The diluted mixture keeps without appreciable deterioration for over two weeks if homologous serum is used. The diluting fluid causes a certain degree of deterioration.

(6) By diluting the serum so that the diluted mixture will give a definite reaction after a longer period there is a possibility of failure of detection should the antigen dilution happen to be higher than expected.

(7) The use of undiluted serum will enable detection of lower concentrations of the antigen, but there is the risk of non-specific reaction. This could, however, be avoided by using as control antisera against other probable antigens.

6. Normal haematological findings in the inhabitants of the United Provinces.

V. S. MANGALIK, Lucknow *and* (MISS) S. CHAUDHURI, Delhi.

In recent years, figures have been published from Bengal, Madras and Bombay, giving maximum, minimum and mean haematological findings in the inhabitants of those provinces. Blood of 101 healthy persons (50 men and 51 women) from the United Provinces has been examined. Oxalated venous blood was used. Standard techniques were employed. Total Red Blood Cell Count, Haemoglobin Estimation, Packed Cell Volume and White Blood Cells were determined. Mean

Corpuscular Volume, Mean Corpuscular Haemoglobin and Mean Corpuscular Haemoglobin Concentrations were calculated. The data have been statistically analyzed. Our findings have been compared with those from other provinces and between males and females of the same series to see if the differences are significant or otherwise. Haematological findings (mean) in healthy persons of the United Provinces are found to be as follows:—

	Males.	*Females.*
R.B.C. in millions ..	5·1 ± 0·31	4·6 ± 0·25
Haemoglobin in grm. % ..	15·48 ± 0·77	13·07 ± 0·61
Packed Cell Volume % ..	47·7 ± 2·16	41·55 ± 1·887
Mean Corpuscular Volume ..	94·07 ± 4·82	91·045 ± 5·44
Mean Corpuscular Haemoglobin	30·544 ± 1·94	28·7 ± 1·7
Mean Corpuscular Haemoglobin Concentration ..	32·8 ± 1·1	31·39 ± 1·07
W.B.C. in thousand in c.mm.	7·98 ± 1·36	7·265 ± 1·169

7. Preliminary observations on haematological survey of poor class families in and around Lucknow.

V. S. Mangalik, Lucknow.

Fullerton (1936), working under Professor Davidson of Aberdeen University, made haemoglobin estimations and diet survey of some 3,000 individuals of poor class families in Aberdeen, and showed high incidence of hypochromic anaemias in such families. He attributed this, apart from other causes, to a diet poor in iron. Work on similar lines has been started in Lucknow. Persons with family income of Rs.15 per month or less have been included, mostly employed as domestic servants, sweepers, washermen, or labourers in the city or in the fields. Record is also being kept of the diet cooked in the family kitchen and consumed by the members. So far 491 individuals have been examined—379 males and 112 females—of all ages. All these people considered themselves in good health. Haemoglobin estimations have been made using Hallige Haemometer. Results are expressed in grams per cent. Mean haemoglobin value for males has been found to be 13·3 grams per cent (97% Hellige) for males, and 10·58 (79% Hellige) for females.

Diet of these people is strictly limited by income and consists of iron-poor carbohydrates. Hypothesis is advanced that in spite of insufficient iron intake, these people show satisfactory haemoglobin levels because of the iron they take in from the iron-utensils in which their food is very often cooked.

Work is still in progress and it is intended to survey at least 2,000 cases. Enquiry is being financed by a grant from the Indian Research Fund Association.

8. Studies in gastric acidity in Indians with alcohol test meal.

V. S. Mangalik, M. P. Goel, *and* (Miss) Hemlata Mangalik, Lucknow.

Alcohol test meal has replaced the old gruel meal in most of the bigger hospitals. Fractional alcohol test meal has been done on 75 patients not showing any sign or symptom pointing to a disturbance of the gastro-intestinal tract. Figures showing maximum and mean acid secretion after alcohol have been worked out and compared with those of other workers in various parts of India. Twenty-nine cases were administered both alcohol and gruel meals on different occasions and the data have been analyzed to show if there is any significant difference in the gastric response to both types of meals. Cases have been classified into six arbitrary acid groups (Napier, 1938). Acid response has been studied according to community, sex, influence of diet and age. Some cases of achlorhydria have been studied and the relative difference between apparent achlorhydria and true histamine-fast achlorhydria is discussed.

A study has also been made of gastric response in relation to various types of anaemias.

9. Studies on serum calcium in normal and tuberculous subjects.

B. B. Rai *and* N. D. Kehar, Izatnagar.

It has been commonly believed that tuberculosis is associated with demineralization. Calcium is of vital importance in maintaining the physiological integrity of the body. In order to investigate the rôle of calcium in tuberculosis, a comprehensive study has been made, in the first instance, of the serum calcium level in normal men and women of different ages and also of patients in different stages of tuberculous infection. The effect of administering different proprietary and laboratory preparations of calcium on serum calcium with and without vitamin supplements has also been studied.

10. Tuberculosis in an elephant.

M. R. Mahajan, Ajmer-Merwara.

The paper records a case of tuberculosis in an elephant diagnosed at post-mortem examination. The lesions were confined to the intestines and left lung only. Material sent, was confirmed at the Imperial Veterinary Research Institute, Mukteswar. The strain of tubercle bacilli concerned appeared to be that of bovine type.

11. Fluorosis in cattle in India.

S. N. Ray, Izatnagar.

Investigations are now under progress in order to study the question as to whether the osteomalacia-like symptoms in cattle, found in various parts of India, are due to fluorine intoxication. From the reports of the Disease Investigation Officers of Madras and Hyderabad (Deccan), it was known that osteomalacia-like diseases or chronic rheumatic arthritis are endemic in those areas where chronic fluorosis—as exhibited by mottled enamel—is prevalent among human beings. A micromethod for the estimation of fluorine in biological materials has been perfected so that concentrations—as low as 25–30 mg.—can easily be estimated, the error at this low level being not more than 10%. Chemical examinations of teeth of a few diseased animals by this method revealed a higher concentration of fluorine (2-3 times more) as compared to the amounts present in normal samples. A number of water samples collected from the affected areas were also examined and concentrations from 0·60 p.p.m. to 2·01 p.p.m. were found. The corresponding values for water samples from unaffected areas were found to be 0·1 to 0·28 p.p.m. The high concentrations of fluorine in waters from the affected areas as well as the high fluorine contents of the teeth of afflicted animals make it probable that fluorosis may be widely prevalent in various parts of India.

12. Some helminths of domestic animals in Coorg.

G. D. Bhalerao, Izatnagar *and* C. K. Kalappah, Somawarpeth.

A small collection of helminths was received from Coorg and it comprised twenty-one species, of which five were obtained from horses, one from a hare, four from cattle, two from buffaloes, six from dogs, two from a fowl and one from a sheep. *Trichocephalus laporis* is recorded for the first time from India. *Ancylostoma braziliense* appears to be fairly common and *Gyalocephalus capitatus* extremely rare in the south of India. The males of *G. capitatus* have not yet been recorded from India.

13. The economics of the milk industry in India.

B. MUKHERJEE, Lucknow.

Importance of milk in national dietary: Its chemical constituents. A perfect food without substitute.

Its dangers: Carrier of disease. Infection visible and invisible. Random samplings in London show 10% milk tainted from tubercular cattle.

Guarantee of purity: Ways to it. Methods in Western countries. Grades and standards of purity. Certified, Grade A and Pasteurized milk. Food and Drugs Act.

Indian milk industry: Inadequate supply. Poor quality. Public not quality-conscious. Demand determines quality.

Low *per capita* consumption.

Causes of deplorable condition. Need of propaganda. People gets the milk it wants.

Uncontrolled erratic breeding. Socio-religious prejudices keep on useless uneconomic cattle—pressing on grazing and fodder. Steady deterioration in cattle.

Poor cattle and pure milk go ill together. One excludes the other.

Cattle feeds defective: Malnutrition creates vicious circles. Grazing limited and annually getting less. Herd Books.

High temperatures cause rapid deterioration. Unhygienic production methods. Improved methods of handling milk. Limited water-supply and milking sheds in villages. Dust infection.

Risks of adulteration: Drastic powers necessary. Medical examination of cattle essential. Risk of tuberculosis.

Defective distribution: Quickest transport essential. Economic zone of supply a function of distance and transport. Economic radius varies from 10 to 40 miles according to different transport methods.

Dairy industry—a part of mixed farming. As supplementary industry it gives cover and employment in long periods of enforced uneconomic leisure. Provides balance in rural economy—a cushion absorbing and softening economic jerks.

Processing: Pasteurization.

Economic transport: Every supply centre should be compact and developed to maximum capacity. Scattered undeveloped centres not giving maximum loads make distribution slow and uneconomic—increasing operating costs per unit.

Monopolization of milk marketing would reduce costs but appear top-heavy and anti-social. Local monopolies better—preventing erratic and disorderly marketing.

14. Observations on the life-history and bionomics of the dog-tick, *Rhipicephalus sanguineus* (Latreille).

S. N. SAPRE, Mukteswar.

The larvae, nymphs and adults of *R. sanguineus* feed readily on dogs a few days after emergence. Under favourable conditions the larvae are fully engorged in about 4 to 6 days and become nymphs in about 30 days. The nymphs feed for 5 to 9 days and after engorgement they become adults in 30 to 43 days. Adult females feed for 9 to 15 days. Males are in search of females after feeding for 3 or 4 days. Copulation takes place upon the host, and the numbers of males and females have been found to be approximately in the proportion of 2 to 3. The rate of mortality during the nymphal and adult stages is negligible, but it is relatively high in the larval stage. At 22°C. oviposition commences 3 to 6 days after the gravid female has left the host, and the process occupies 14 to 18 days. The female survives 2 to 14 days after oviposition has ceased. A single female deposits 1,485–3,556 eggs.

15. Observations on the life-history of *Haemaphysalis bispinosa* Neumann.

S. N. Sapre, Mukteswar.

Haemaphysalis bispinosa is a three-host tick. It was reared easily on goats and hill-bulls.

Out of a total of nearly 9,000 eggs laid by seven females, only 600–700 hatched into larvae.

The larvae and nymphs are ready to feed in about 5 to 6 days after emergence. The larvae are fully engorged in 5–10 days. The nymphs remain attached to their host for 6–15 days. The parasitic period of the adult stage has not been worked out. The incubation period of the eggs is about four weeks, and the larval and nymphal periods, counting from the date of engorgement, are 17–24 and 28–34 days respectively at 22°C. As for the proportion of sexes, 63 males and 90 females were counted in a batch of 153 adults.

16. Observations on the biology of *Ornithodorus papillipes* Birula.

S. N. Sapre, Mukteswar.

The average period taken by a female *O. papillipes* for a complete feed on its host is one hour. The larvae feed for 10–20 minutes at each meal, whilst the duration of feed in the first, second and third nymphal stages is 15–25, 25–35, 35–45 minutes respectively and that in the fourth and fifth nymphal stages 45–60 minutes. Copulation occurs shortly after feed. Eggs are deposited in batches at intervals of a few days, the process extending over four to five months. A single female lays 680 to 700 eggs, of which 64 to 88% are fertile. The longevity of adults ranged from 543 to 620 days and that of unfed nymphs in their different stages from 213 to 369 days. Unfed larvae survived for a maximum period of 52 days.

The average durations of the egg, larval and the five nymphal stages were observed to be 19, 15, 18, 21, 22, 28 and 37 days respectively. The number of ecdyses undergone by *O. papillipes* before reaching maturity varied from four to seven, males generally appearing after four moults and females after four to seven moults. The mean minimum period from the egg to the adult stage is 98–125 days in the case of males and 107–167 days in the case of females.

17. Paratyphoid among pigeons in Assam.

V. R. Gopalakrishnan, Assam.

An outbreak of septicaemia among pigeons in Assam, due to *Salmonella typhimurium*, is recorded in this article. Clinical syndrome, post-mortem lesions and laboratory findings are described. Besides, a brief review of literature on the subject is given.

Salmonella infections in birds are not only of scientific interest and economic importance but also of public health significance; therefore the possibility of 'food poisoning' in human beings is discussed as *S. typhimurium* is pathogenic for man.

This would appear to be the first record of a natural outbreak of Paratyphoid (*S. typhimurium*) among pigeons in India.

18. The biological control of Guineaworm in some villages of the Dharwar district.

P. W. Gideon, Dharwar.

The paper is a report on the observations and conclusions on one year's work on the control of guineaworm by means of fish and chlorogen in five villages of Dharwar district.

19. Arsenic content of common foodstuffs.

K. N. Bagchi *and* H. D. Ganguly, Calcutta.

A preliminary note on this investigation was communicated to the Indian Science Congress, 1935. The investigation had to be discontinued on account of some unforeseen circumstances. It was, however, taken up again and completed under the auspices of the Indian Research Fund Association.

The investigation is important from the point of view of the forensic toxicologists who are required to express opinion as to the amount of extraneous arsenic in the stomach contents of suspected case of arsenic poisoning.

About 100 different articles of food were analyzed and the results have been grouped as follows:—

1. Animal food—arsenic content varies from 0·016 mg. (egg) to 3·58 mg. (sea-fish).
2. Vegetables—*nil* (potato, carrot, etc.) to 0·13 mg. (cabbage).
3. Cereals—0·10 mg. (arhar dal, etc.) to 0·24 mg. (rice).
4. Fresh fruits—*nil* (orange, tomato, etc.) to 0·04 mg. (banana).
5. Dried fruits—0·036 (cocoanut) to 0·54 mg. (walnut).
6. Fatty food—0·03 mg. (butter) to 0·18 mg. (hydrogenated fats or Vanaspati).
7. Cooked or prepared food—0·11 (kachuri) to 0·18 mg. (biscuit).
8. Miscellaneous—includes salt, spices, sugar, glucose, rum, waters, baby food, etc.—the arsenic contents of which vary from 0·002 to 0·21 mg.

These figures indicate milligrammes of As_2O_3 per kilo of food materials taken fresh, i.e., in the form in which they are taken or cooked.

Quite a large number of foods of vegetable origin are free from arsenic while those of animal origin are rich in arsenic. Different kinds of sea-fish contain the maximum amounts of arsenic (2·6 to 3·58 mg.). Hilsa fish (3·0 mg.) appears to belong to this class of fish. Lobsters (fresh water) do not contain large quantities of arsenic as found by the European observers in sea-water prawns.

20. Nutritional investigations on fish. Part 1. The nicotinic acid content.

M. L. Khorana, M. L. Sarma, *and* K. V. Giri, Waltair.

The nicotinic acid content of a large number of economically important food fishes in the Northern Circars has been determined by the adsorption method of Giri and Naganna (*Ind. J. Med. Res.*, **29**, 125 and 585). The nicotinic acid content of the majority of fishes ranged from 1·2 to 2·9 micrograms per 100 grams of the muscle tissue.

21. Study of mental diseases—indication for a new angle of vision in medical education and practice.

NAGENDRANATH DE, Calcutta.

Psychiatry is rapidly, but none too early, acquiring an important place in the field of medicine. Physicians have always recognized that some physical symptoms are purely of psychic origin. These they have termed functional and hysterical. More intensive study of mental diseases during recent years has revealed their closer relations even with the diseases of the body which are not merely functional in nature. The relation between mental and physical diseases has been brought out in the following lines.

Many symptoms and diseases hitherto known to be of purely physical origin have now been shown to be psychogenic. Bad taste in the mouth may occur only as an early symptom of paranoia. We have seen epidemic of psychogenic vomiting among girls in a school. Many cases of intestinal colic, so-called chronic appendicitis, colitis and leucorrhoea are due to irritation of the autonomic nervous system resulting from emotional imbalance. Tics and habit spasms are more often psychogenic than not. Spasmodic torticollis results as a symbolic defense against anxiety. Asthma is psychogenic in many cases specially in children. Struggling for breath is a very suitable symptom for a neurotic who wants to attract sympathy from people around him.

In some diseases, psychic factor is being recognized as all-important. Even cardiologists do now admit that what they called 'effort syndrome' is really an anxiety syndrome. In cases of hyperemesis gravidarum obstetricians no longer look for evidence of hypothetical toxins in the liver but have realized that the cause is, in most cases, psychic.

Investigation of the mind has provided clues to the etiology of some diseases of unknown origin. A state of chronic anxiety has been found in most cases of thyrotoxicosis with or without hyperplasia of the gland, and relief of anxiety by psychotherapy has been followed by relief of symptoms of thyrotoxicosis. Symptoms and signs of co-called essential hypertension have been observed to arise as conversion phenomena in hysteria and during analysis have been completely replaced by pure anxiety.

Psychic condition is an important contributory factor in some diseases of known etiology. We know that pulmonary tuberculosis is a definite bacterial disease but cannot answer why all of us do not suffer while pathologists find evidence of infection almost in every lung that comes to their hands. Psychiatrists' claim that the disease occurs mostly in persons of schizothymic type, who are habitual shallow breathers, is worth investigating.

Prolonged functional hyperactivity leads to structural alteration in the organs concerned. Fixation of libido in the urethral level leads to the habit of drinking gallons of water in order that lots of urine may be passed to satisfy the libido. The stress entailed on the circulatory and excretory systems may lead to structural alterations in them and even to their ultimate failure.

Even grosser structural changes are now being proved to be produced by psychic conditions. Pressure diverticula of the oesophagus have been shown to result from spasm of the oesophagus of purely psychic origin. Serial roentgenograms have revealed in many cases that the size of gastric ulcers increases with worry and diminishes rapidly when that is quietened. Frequency of micturition simply for the pleasure of the act may lead to contraction of the bladder to a tenth of its capacity. Allergic conditions like urticaria and eczema are found more frequently in families of mental diseases than elsewhere and in many cases urticaria appears under mental tension and disappears during quieter period. Among other skin diseases psoriasis has been found to recur in isolated attacks of depression and clear up during intervals.

Conversely, physical condition also is responsible for some mental disease. Apart from organic psychoses, previous physical illness often sets the pattern of mental symptoms, and physical defects are potent sources of psychoneuroses and psychoses.

In the sphere of therapeutics also, many of the drugs used for their somatic effects have profound effect on the mind of the patient. Every student of pharmacology should know them along with their somatic effects. Surgical and gynaecological operations which result in permanent defect, debility, deformity or disability, e.g., amputation of a limb, ankylosis of a joint, enucleation of an eye, removal of the testes, ovaries or the uterus, have mental repercussions much more severe than are usually thought of.

Knowledge of psychiatry is necessary for proper evaluation of the history given by the patient. A patient with bodily delusions may manufacture such stories as are liable to lead the physician astray if he is not vigilant about the possibility.

The above are only a few of the instances of psychosomatic relation with which the general practitioner must be conversant in order to be able to treat his patients well. They are the indications for—

(1) award of a better place, than at present, to psychiatry in the curriculum of the degree examination in medicine in the Universities;
(2) inclusion of psychiatry in the curriculum of licentiateship examination in medicine;
(3) arrangement for post-graduate courses in psychiatry to train up specialists in the subject;
(4) provision for some indoor beds and outdoor-clinics for mental patients in every teaching hospital.

Many of the patients suffering from mental diseases are suitable for being treated in general hospitals. Out of 1,360 patients who attended the psychological clinic attached to the Carmichael Medical College Hospitals, Calcutta, only 66, i.e., less than 5%, were unsuitable for being treated in a general hospital. Throwing all mental patients into a mental hospital which, in the public mind still bears the stigma of an asylum, is in itself derogatory to the welfare of the patient and in a few weeks patients are liable to develop what may be called 'asylum psychosis'. In America some of the general hospitals have already got wards for mental patients. In England most teaching hospitals have got psychiatric clinics attached to them and the St. George's Hospital is going to 'have its properly equipped and adequately staffed psychopathic ward when it moves into its new premises'.

22. The rôle of protozoa in activated sludge.

S. C. Pillai, Bangalore.

The rôle of protozoa in activated sludge, as in the soil, has not been understood so far. The author's studies have shown that the protozoa in activated sludge as a group are much more efficient in sludge formation and clarification of sewage than any single strain or combination of bacteria isolated from the sludge. Among the protozoa, the species of *Epistylidiae* and *Vorticellidiae* gave much the best results. The morphological and physiological properties of these protozoa enable them to act as efficient biological flocculants. In addition to clotting and sludge formation, they promote the conditions necessary for nitrification. The resultant sludge, being largely constituted by these protozoa, holds up a considerable part of the nitrogen and other fertilizing ingredients originally gained from the sewage. Thus, floc formation, the related progressive oxidation changes, and the conservation of the fertilizing elements in the activated sludge process are profoundly influenced by the occurrence of protozoa especially of the species of *Epistylidiae* and *Vorticellidiae*, which are found to thrive best in the aeration tanks and in all seasons of the year.

23. A case of pseudotuberculosis in the goat.

V. R. RAJAGOPALAN, Mukteswar.

A case of pseudotuberculosis in the goat which appears to be the second record in the world is recorded. The symptomatology, gross pathological anatomy and histopathology of the condition are described. A study was made of the causal organism which has been determined as *Pasteurella pseudotuberculosis*, Group I.

SECTION OF AGRICULTURE

President:—NAZIR AHMAD, O.B.E., PH.D., F.INST.P., J.P., F.N.I.

Soils and Agricultural Chemistry

1. A preliminary note on the amelioration of saline soil by tannate compounds.

T. J. MIRCHANDANI, Sakrand.

Salinity in Sind soils is due to the presence of sodium chloride and sodium sulphate in large quantities. A method known as 'leaching and cropping' has been devised to reclaim saline soils with sandy or at least fairly light sub-so : The method, however, fails to reclaim lands with impervious sub-soil. In an effort to evolve a method of reclaiming this type of saline lands, Babul (*Accacia arabica*) bark, and khabar (*Salvadora* species) leaves (which contain tannate compounds in large quantities), were incorporated into the soil at the rate of 80 mds. per acre. These two treatments along with others were randomized in four blocks and bajri, berseem and cotton 27 W.N. were grown on them in successive seasons. The yields of all the three crops were much below the normal, but the crop was established where none grew before. The treatment differences were not significant. This is presumably due to the lack of uniformity of salinity, in extent as well as in concentration, within the plot, and between plots.

A sand culture experiment with wheat showed that in presence of 0·5% sodium chloride, the khabar leaves and babul bark, in green manure doses, gave 28% and 45% germination respectively, the control giving only 7%. It is difficult to say at this stage whether this is due to chemical combination or only mechanical action. The work is being extended to the field in the individual plots. The chemical aspect of the problem is being studied in the laboratory.

2. A study on nitrogen fluctuation in an acid soil.

H. N. PAL, Jorhat (Assam).

The paper describes a preliminary investigation on the comparative study of the periodic fluctuation of nitrogen in the Jorhat Farm soil (0-1′), a typically acid soil of alluvium, green-manured with cowpea, dhaincha and sunnhemp in the rains of 1940 and subsequently grown with sugarcane (POJ. 2714). 'Loss on ignition', an important factor associated with soil nitrogen study was also estimated and compared. Four treatments were under comparison: (1) cowpea green-manured, (2) dhaincha green-manured, (3) sunnhemp green-manured, and (4) control. Estimations were made at about bimonthly intervals from November 1940 to July 1941. The nitrogen contents in November under treatments 1–4 were ·106%, ·10%, ·096% and ·092% respectively.

There was periodic rise and fall in the nitrogen content under each treatment. Excepting treatment 2, others showed a striking similarity, each showing a rise in January, followed by a fall in March and so on. Treatment 3 showed maximum rise in May (·161%), so also treatments 1 and 4 which gave ·124% and ·138% respectively. Treatment 2 showed a continuous rise from November to March, followed by a fall in May and then a rise in July, the maximum being reached in July (·136%).

Regarding 'loss on ignition', variations were small and irregular, excepting for treatment 3.

3. The vertical and horizontal shrinkage of black cotton soil at Mandalay, Burma.

A. T. SEN, Dacca.

In course of an investigation into the cause of excessive and continual warping and cracking of buildings constructed in Mandalay, Burma, it appeared, although the data given in this paper is not conclusive, that there is a tendency for the horizontal contraction of the Mandalay soil (in the process of drying) to exceed the vertical contraction.

4. A note on the vertical translocation of phosphates in some Indian red soil profiles.

M. K. MUKHERJEE, Dacca.

Observations have been made on vertical translocation of phosphorus in five profile samples. It was found that there was a minimum quantity of phosphorus at an intermediate depth. The surface layer was found to contain the maximum amount of phosphorus soluble in hydrochloric acid. No regularity was observed in the case of available phosphorus, neither did it show any relation with the per cent organic carbon, nor with that of silt or clay.

5. Sodium carbonate treatment of çanal beds for minimizing seepage of water. Part III.

M. R. NAYAR *and* K. P. SHUKLA, Lucknow.

1. In the treatment of pure Calcium soil with Na_2CO_3 the soil colloids swell, and the swelling is found to depend on two factors:—

(*a*) *The degree of saturation of the zeolite complex with respect to sodium ions.*—The addition of Na_2CO_3 results in Na^+ ions displacing Ca^{++} from the Ca soil. The quantity of the Na^+ entering the complex is directly proportional to the concentration of Na_2CO_3 in the soil solution; hence with increase in the quantity of Na_2CO_3 the amount of Na^+ progressively increases and that of Ca^{++} decreases, till when the soil gets saturated with Na^+, it attains the maximum swelling. *Any further increase of Na_2CO_3 tends to supress swelling.* Soils having greater 'base exchange capacity' show more maximum swelling than those having less.

(*b*) *The presence of the products of exchange reaction.*—As a result of reaction between Ca-soil and Na_2CO_3 some $CaCO_3$ is formed. The $CaCO_3$ when present in sufficient quantity supresses the swelling of Na-soils. This is why there is a decrease of swelling after the maximum has been reached. This effect is not noticeable in H-soil + Na_2CO_3 mixtures or in pure sodium soils.

2. (*a*) $CaCO_3$ reacts with Na-soils according to the equation:—

$$CaCO_3 + 2Na(Z) \rightleftharpoons Ca(Z) + Na_2CO_3.$$

But it has been found that the reaction to the right soon reaches a limit and cannot be brought to completion by increasing the quantity of $CaCO_3$ only.

(*b*) Dissolution of $CaCO_3$, however, is not the same with soils saturated with different cations. The restoration of Ca to the soil complex is influenced by the presence of cations in the complex and follows the series:

$$H > NH_4 > Na > K > Ba.$$

3. The effect of mixing various sodium salts to a heavy Ca-soil, is to make it impermeable due to production of Na-soil. But the impermeability effect seems to follow the series:

$$Na_2C_2O_4 = Na_2CO_3 > NaHCO_3 > NaOH = NaCl > \text{Na-acetate} = NaNO_3 > Na_2SO_4.$$

4. The impermeability of pure sodium soil decreases with the addition of NaCl. It goes on decreasing with the increase in the quantity of NaCl. But small amounts of NaCl (even up to 1%) have no pronounced effect on the impermeability.

5. Usar soils have been found to be good substitutes for soil-soda mixtures as a lining material. This method of lining has been tested both in the laboratory and small guls, and has proved as satisfactory as the Sodium Carbonate method of lining.

6. Effect of lime, gypsum and magnesia on the transformation of soil phosphorus.

M. O. GHANI *and* S. A. ALEEM, Dacca.

An acid soil, having a very low amount of available phosphorus, was incubated with calcium carbonate, calcium hydroxide, calcium sulphate and magnesium oxide each at the rate of 5 tons per acre at 30°C. Transformation of soil phosphorus was studied by fractionating the samples at intervals of 4, 6, 8 and 10 weeks. The available phosphorus regularly increases with time in all the treatments; in some cases the fraction is almost trebled after ten weeks. Magnesia and lime are the most effective for the purpose, calcium carbonate least and the calcium sulphate occupies an intermediate position. The organic phosphorus fraction decreases with time in all cases whereas iron and aluminium phosphates remain practically unaffected by the above treatments. The increased availability is, therefore, due to the breakdown of organic phosphorus compounds at a higher *p*H and not due to chemical interaction of the liming materials with the phosphates of iron and aluminium.

7. The fractionation of phosphoric acid of some Indian soils.

M. O. GHANI *and* S. A. ALEEM, Dacca.

The distribution of different phosphorus compounds in some Indian soils has been studied. In acid soils, the acetic acid soluble fractions (mono- and di-calcium phosphates) are very low, while alkali soluble inorganic fractions (presumably iron and aluminium phosphates) are very high. In neutral soils, they occur in the reverse order. Under alkaline conditions acetic acid soluble fractions decrease while sulphuric acid soluble phosphorus (phosphates of apatite type) increases. The organic phosphorus is closely related to the carbon content and *p*H of soils, showing that its accumulation in soil is a function of microbiological activities. About 25% of the total phosphorus is in the insoluble fraction.

The availability of soil phosphorus is mainly a function of soil reaction. Unavailability under acid conditions is due partly to the formation of insoluble iron and aluminium phosphates in presence of free sesquioxides and partly to the accumulation of organic phosphorus compounds. Unavailability under alkaline conditions is partly due to the formation of insoluble apatites in presence of calcium carbonate and partly to lower rate of decomposition of organic phosphorus. High availability under neutral conditions is due to the absence of these two types of fixation and rapid mineralization of organic phosphorus.

8. Displacement of Al from subfractions of hydrogen clays by neutral salts.*

J. N. MUKHERJEE *and* B. CHATTERJEE, Calcutta.

The amounts of Al displaced by 0·17 N $BaCl_2$ from six subfractions of the entire hydrogen clay fraction of a non-lateritic calcareous soil from the Padegaon Farm have been determined. The displaced Al increases from 8·0 to 27·0 milli-equivalents per 100 g. of colloid with decrease in the particle size up to the fifth fraction which has particles whose average equivalent spherical diameter is approximately 0·0175 micron. The sixth fraction has particles of diameter $<$ 0·015 micron but gives a markedly lower value (15·5 milli-equivalents per 100 g.). The sixth fraction has also a smaller base exchange capacity compared with the others.

9. Variations in the base exchange capacity of hydrogen bentonite observed on titrating aqueous suspensions having different colloid : water ratios.*

J. N. MUKHERJEE, R. P. MITRA, *and* S. P. RAY, Calcutta.

The base exchange capacity (b.e.c.) of a hydrogen bentonite having particles with average equivalent spherical diameter 0·075 micron and separated from the entire clay fraction of a neutral Indian bentonite by controlled centrifugalization in a Sharples super centrifuge has been determined by potentiometric and conductometric titration of its aqueous suspensions having different amounts of the over-dried colloid per litre. An 18% increase in the b.e.c. calculated at the inflexion point of the titration curves has been observed on changing the colloid content from 1·0 to 10·0 g. per litre. On the other hand, the hydrogen bentonite from the entire clay fraction and hydrogen clays prepared from a number of soils gave a constant b.e.c. independent of the colloid content of the sol. Results of separate determinations at a fixed colloid : water ratio agree within $\pm$ 2·5%.

10. The free and total acidities per particle of hydrogen clays and hydrogen bentonites.*

R. P. MITRA *and* S. P. RAY, Calcutta.

Hydrogen clays and hydrogen bentonites having equivalent spherical diameters ranging between specified limits calculated from rates of centrifugal subsidence have been isolated from the entire clay fraction of a calcareous soil and a neutral bentonite. Their free and total acids *per gramme* have been obtained respectively from the e.m.f. of a hydrogen electrode placed in a 0·25% suspension and from the inflexion point of potentiometric titration curves with caustic soda. If T is the free or total acid, the corresponding quantity *per particle* is $rDT/3$ where r is the average equivalent spherical radius and D, the density. Also the *number* of free H^+ ions or the total number of H^+ ions per particle is the product of the free or total acid per particle and Avogadro's number. It has been found that the number of free H^+ ions associated with the coarser particles is of the order of 10^6 and the total number of H^+ ions of the order of 10^8. The number of both free and titrable H^+ ions rapidly decreases with

* The work has been carried out under the scheme of research financed by the Imperial Council of Agricultural Research, India.

diminishing particle size. However, each particle of the finest fractions has as many as 10^8 H^+ ions. The titration curves, however, reveal a weak monobasic acid character of the hydrogen clays and a strong dibasic acid character of the hydrogen bentonites. The ratio of the free to the total number of H^+ ions is less than 0·05 with all the hydrogen clays. This is consistent with the weak acid character of their titration curves.

11. On the chemical and physico-chemical transformations in soils by application of factory waste product.

K. L. KHANNA *and* S. C. SEN, Bihar.

The present investigation is a continuation of the previous work done in Bihar and undertaken with the object of finding out the causes of variations in cane productions in the same type of soil by the application of molasses and press cake from two different processes. The chemical and particularly the physico-chemical transformations in soils brought about by their applications are expected to throw considerable light on this aspect and, therefore, detailed study of the periodic changes in soils was carefully made. The salient features so far revealed are: (i) The exchangeable Ca cation is found to increase appreciably at the cost of exchangeable alkali ions in plots treated with sulphitation molasses or press cake. The exchange capacity is also found to vary considerably decreasing progressively in these treatments and is significantly correlated with cane yield. (ii) The water soluble nutrients, calcium and potassium, are considerably more in plots treated with sulphitation products as compared to the carbonitation ones in spite of lime being present in nearly double the quantities in acid extract of the latter. (iii) The distribution of organic carbon in soil system affected by the application of different doses of molasses and press cake to soil was not studied. The rate of fermentation is, however, found to differ with different grades of molasses and press cakes this being greater in the case of sulphitation products. (iv) The greater lowering of hydrogen ion concentration is observed in plots treated with sulphitation products than those treated with the carbonitation ones, owing to formation of weak organic acids in the system. (v) In hydrochloric acid extracts, sesquioxides in sulphitation press cake and carbonitation molasses treated plots are found to be in slightly higher concentration than in other treatments. The principal phosphoric anion is, however, found to gradually diminish in the sulphitation products. (vi) The total and nitric nitrogen are found to increase on long exposure.

12. Application of the potassium ferricyanide method for the estimation of organic carbon in calcareous soils.

K. L. KHANNA *and* S. C. SEN, Bihar.

The standard dry combustion method for the estimation of organic carbon being complicated, laborious and time consuming, the wet combustion method has recently become popular among the soil scientists. Of these the acid permanganate method by Nostitz; the alkaline permanganate method by Puri and potassium dichromate method by Walkley and Black are commonly used. In dealing with soils highly calcareous in nature the authors experienced much difficulty in the application of permanganate methods for the estimation of organic carbon. Alkaline potassium ferricyanide has been very successfully used by the authors for the estimation of reducing sugars in cane juice and carbohydrates in cane leaves, and attempts were therefore made to estimate organic carbon in soil with alkaline potassium ferricyanide solution and results comparable with those from the standard dry combustion method and Walkley and

Black's wet reaction method were obtained. The experimental procedure is described and the results obtained by all the methods are discussed.

13. Cakes and their nitrogen release in calcareous loam.

K. L. KHANNA *and* S. C. SEN, Bihar.

North Bihar soils are generally rich in potash sometimes as high a value as 1·0% (generally 0·5–0·7 P_2O_5). The phosphate content is not high and nitrogen is extremely deficient, i.e. 0·02-0·03%. In view of the light nature of soils the use of organic nitrogenous manures supplemented by phosphatic manures is advocated. No information, however, is available regarding the comparative value of different cakes and other easily available organic manures, and the present study was an attempt to find out the nitrogen release value of different cakes alone and in combination with superphosphate. The results showed that (i) cakes show better and quicker release when they are supplemented by superphosphate, (ii) castor cake is the quickest to become available while Mahua is the slowest, (iii) the amount of N fixed was maximum in Farm Yard Manure followed in descending order by compost, castor cake, mustard cake, groundnut cake, Press-mud and Mahua cake. The deleterious effect of high fat content in mustard cake under an uncertain environment from the point of view of moisture is brought out.

14. Maximum base exchange capacity of soils.*

J. N. MUKHERJEE, S. K. MUKHERJEE, *and* S. L. GUPTA, Calcutta.

In an investigation on the base exchange capacity (b.e.c.) of H-soils † and naturally occurring acid soils ‡ it has been observed that the method of Schofield using half neutralized *p*-nitrophenol, *p*H 7·1, gives the highest b.e.c.§ This paper deals with experiments which were undertaken to ascertain whether there is a maximum limit to the amount of H ions associated with a soil capable of reaction with bases. Using a H-soil ‖ and Schofield's method the b.e.c. has been observed to depend on the soil : water ratio as shown below :—13·9, using 4 g. soil + 50 c.c. solution and 11·5, using 5 g. soil + 40 c.c. solution. On repeated treatment, however, of the same mass of soil with fresh solutions of the reagent a constant value (15·8, 15·4) was obtained. This constant value was about 70% higher than that obtained either by Schollenberger's (9·3) or Parker's method (9·0) and about 15 to 30% higher than that obtained by single treatment with Schofield's reagent. The conductivity method of Schofield in which a phosphate buffer is used gives a much lower value (6·7). The amount of lime taken up from a solution of phenol half neutralized with lime of *p*H 8·5 is about 15 (14·8, 14·9) and this high value evidently arises from the higher *p*H. With one H-soil, ¶ however, repeated treatment with half neutralized *p*-nitrophenol gave a slightly lower b.e.c. (10·7, 10·5) than Parker's method (11·3, 11·3). In view of the exceptional nature of this observation the amount of Ca^{++} taken up by reaction with half neutralized *p*-nitrophenol was directly determined by leaching with NaCl according to Hissink-Tiulin. The values obtained by these methods are 14·3 and 14·8 for the Krishnagar H-soil and 10·5 and 10·4 for the

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* The work has been carried out under the scheme of research financed by the Imperial Council of Agricultural Research, India.

† Soils rendered completely unsaturated by exhaustive leaching with *N*/20 HCl.

‡ Partially unsaturated soils.

§ Observed with four different soils and two hydrogen clays.

‖ Prepared from the Krishnagar Farm soil.

¶ Prepared from the Kalyanpur Farm soil.

Kalyanpur H-soil. Both methods thus show fair agreement. Further estimation by Hutchinson-McLennan method gave a value of 10·4 and increasing the Ca^{++} concentration from $\frac{N}{60}$ used in this method to $\frac{N}{2}$ by adding neutral $CaCl_2$ gave an identical value (14·4). The higher value obtained by Parker's method in this case is probably due to the fact that in this method the cation involved is Ba^{++} instead of Ca^{++}. Further, Ba^{++} adsorbed by the Kalyanpur H-soil from a neutral normal solution of $Ba(SCN)_2$ was higher (12·9) than that obtained by Parker's $BaAc_2$ method (11·3). The discrepancy between these two values is probably explained by the fact that the equilibrium pH in the case of $Ba(SCN)_2$ remains unaltered throughout whereas with $BaAc_2$ a lowering of pH from 7·0 to 6·4 was noticed in the initial stages of leaching.

15. The study of some pan soils of the Bakharganj District.*

J. N. Mukherjee, S. K. Mukherjee, *and* N. P. Datta, Calcutta.

Examination of some char lands in the Bakharganj District reveals a characteristic hard layer occurring at a depth not exceeding 1′ 6″ below the surface. A large number of profiles have been examined in chars recently formed and in lands raised above the water level about 200 years ago. The hard layer has been found so far to occur only in the older chars. Field observation shows that the profile characteristics of these pan soils are as follows:—

The surface soil is somewhat loose, either loamy or sandy and sometimes deposited in layers. This is followed by a transitional layer which is a grey coloured loam. The horizon just below this is a stiff clay pan, darker, compact and possesses a prismatic structure; low porosity; high clay content and is soapy to touch; there is weak or no effervescence with HCl. The lower horizon is a transitional layer between the horizons above and below it and possesses a prismatic structure; it is clayey and sticky and gives weak or no effervescence with dilute HCl. The pan horizons possess the following general features:—

1. Appear less moist to the touch in comparison to the layers above and below.
2. Compact and hard.
3. Contain a much higher percentage of clay and silt and especially of the former.
4. Have either a prismatic or column-like structure.
5. Carbonate content and CaO/MgO ratio are definitely lower.
6. Total pore space as also the air space are very low.
7. Percentages of Al_2O_3 and of material soluble in HCl have the highest and of silica soluble in Na_2CO_3 the lowest values compared to the other horizons.

At a sufficient depth, usually below 6′, the deposit is made up of alternate layers of clay and silt 2 to 3 mm. thick and of coarse sand. These characteristics enable the formulation in broad outline of the process of their formation.

16. Cation exchange in mixed clay salts.*

S. K. Mukherjee *and* R. M. De, Calcutta.

Clays containing more than one kind of cation have been called mixed clay salts. According to the nomenclature of Wiegner and Renold

* The work has been carried out under the scheme of research financed by the Imperial Council of Agricultural Research, India.

a mixed clay prepared by first adding potash and then baryta to a hydrogen clay is designated as Ba-K-clay. By adding the alkalis in the reverse order, a K-Ba-clay is obtained. K is more firmly bound in the former and Ba is more firmly bound in the latter.

A K-Ba-clay and a Ba-K-clay were prepared from the H-clay of an Assam acid soil by adding the above bases in amounts equivalent to half the base exchange capacity. Ba to K ratio is thus 50 : 50. Ca- and NH_4-clays were prepared from the H-clay of a Padegaon soil and NH_4-Ca-clay and Ca-NH_4-clay were prepared by leaching respectively the Ca-clay with NH_4Cl and NH_4-clay with $CaCl_2$. The Ca : NH_4 ratio in Ca-NH_4-clay was about 1 and that in NH-Ca-clay about 2.

It was found that HCl liberated a smaller amount of Ba from K-Ba-clay than from Ba-K-clay. Similarly $BaCl_2$ liberated a smaller amount of K from Ba-K-clay than from K-Ba-clay. $CaCl_2$ and $AlCl_3$ displaced larger amounts of K and smaller amounts of Ba from K-Ba-clay than the respective cations from Ba-K-clay, although Ba and K are present in equal proportions in both the clays. NH_4Cl liberated a larger quantity of Ca from Ca-NH_4 clay than from NH_4-Ca-clay although the amount of Ca in the latter is much higher. These results have been discussed in the light of the observations of Wiegner and Renold.

17. A new method for the determination of silt and clay in soils. The buoyancy technique.

(MISS) G. SHARADA BAI, B. SANJIVA RAO, *and* K. S. GURURAJA DOSS, Bangalore.

The silt and clay content in a soil suspension can be computed measuring the density of the soil suspension. Puri has devised a chainohydrometer for determining the density. In the present work it is shown that the same can be determined more conveniently and more accurately by measuring the buoyancy suffered by a cylindrical bulb immersed in the suspension. The loss in weight is determined by a special continuous reading balance devised in this laboratory. The centre of buoyancy of the bulb can be determined by Puri's graphical method. An alternative procedure, which is simpler, is given in this paper. A few soils have been examined for their silt and clay contents by this method and the results compared with those obtained by the pipette method.

18. Live supporting of mango grafts in the field.

S. S. BHAT, Baroda.

Live supporting of defective mango grafts by raising mango seedlings *in situ* prevails in Gujerat. Though its superior merits are not experimentally proved, this practice strengthens nursery-made mango grafts in the field, and saves them from dying, which is otherwise common.

A new method of enarching thinner seedlings grown *in situ* with thicker and older scions in the process of live supporting has been devised by the writer and is found to work very satisfactorily. This method is somewhat of a mean between budding and enarching.

19. Determination of wilting coefficient.

S. D. NIJHAWAN *and* GIRDHARI LAL, Rohtak (Punjab).

Available moisture is an important concept, as the growth and development of a crop depend on it rather than on total moisture. Available moisture may be determined by subtracting wilting coefficient from total moisture. The direct method of finding wilting coefficient by growing crops under a limited supply of water is lengthy and tedious, and therefore indirect methods of computing it from soil constants by the formulas worked out by Briggs and his co-workers have been examined. It has been observed that wilting coefficient calculated from moisture equivalent was very high, but that computed from water-holding capacity and hygroscopic coefficient agreed closely with that found by actually growing the crops. Wilting coefficient varied with clay and, clay and silt content of soil, increasing with increase in the latter. Under field conditions the total amount of moisture did not explain the cause for wilting of Bajra (*Pennisetum typhodium*) but the available moisture, found by subtracting wilting coefficient from the total moisture, showed that wilting was due to deficiency of moisture. Available moisture, thus found, seems to be true index of the moisture status of a soil, while total moisture results may be misleading.

20. Cultivation studies under dry farming. Some characters of the soil aggregates in a cultivated soil.

S. D. Nijhawan *and* Lekh Raj Dhingra, Rohtak (Punjab).

Ploughing breaks the soil into soil aggregates of different sizes. Cultivation with country plough results in the formation of maximum amount of soil aggregates below 1 mm. (33·6%) and minimum amount of those between 3 mm. and 1 mm. (11%), 21% of soil aggregates of more than 1½″ in diameter and 36% of those between 1½″ and 3 mm. in size are present. The soil aggregates between 3 mm. and 1 mm. retain more moisture, and have higher percentage of organic matter, total nitrogen and exchangeable calcium, than all the other soil aggregates of different sizes. Hygroscopic coefficient and moisture at 50% R.H. are also maximum in the soil aggregates between 3 mm. and 1 mm. All these ingredients are present in least amount in the soil aggregates lower than 1 mm. Clay and silt combined in soil aggregates below 1 mm. is less by 11% when compared to soil aggregates bigger than 1 mm. in size. Absence of aggregates between 3 mm. and 1 mm. in a seed bed makes it comparatively impervious. All these physical and chemical characters examined point out that the aggregates between 3 and 1 mm. in size are most active, and therefore any cultural practice whether manurial, rotational or of cultivation which aims at producing such aggregates is the best. Too much pulverization of the soil resulting in the formation of higher percentage of particles below 1 mm. should be avoided. These results further suggest that, for evolving a suitable cultural practice, examination of its effects in soil is necessary, and the adoption of only trial and error methods, which depend for their effectiveness on the yields, may be misleading.

21. Peptization of calcium bentonite by various sodium phosphates.*

N. C. Sen-Gupta *and* Gurbachan Singh, Khodaung (Burma).

A number of polyphosphates were prepared by fusing together ortho-, pyro- and hexameta-phosphates in stoichometric proportions. Peptization of a natural calcium bentonite suspension by these polyphosphates was studied. The efficiency of peptization decreases as follows in the clay fraction:

$$Na_9P_7O_{20} > Na_6(PO_3)_6 > Na_6P_4O_{13} > Na_4P_2O_7 > Na_5P_3O_{10} > Na_3(PO_4).$$

The sand fraction (·03–·05 mm.) of the bentonite was treated with centimolar solutions of the various phosphates. The endosmotic speed.

* Carried out in the Research Laboratories, B.O.C. (Burma Concessions) Ltd., Khodaung, Upper Burma.

under constant potential gradient, as measured using Mukherjee's method, was found to vary in the following order:—

$$Na_9P_7O_{20} > Na_6P_4O_{13},\ Na_5P_3O_{10} > Na_6(PO_3)_6 > Na_3PO_4 > Na_4P_2O_7.$$

Study of Crops and Crop Products

22. A method for estimating crop yields in experimental areas having saline patches.

N. P. Mehta, Sakrand.

Saline soil patches in otherwise sweet lands are common in Sind. Therefore, in field experiments, the yield figures obtained do not give a reliable estimate of the performance of the area nor of the effect of treatments, if any, as these saline patches continue to remain bare and unable to support plant life.

In order to overcome this masking effect introduced by the unavoidable saline patches in experimental areas, a special sampling technique was explored. The sampling method adopted in estimating yield data in the case of experimental plots, which have been subjected to earlier plant samplings for other analyses, was employed.

In a uniformity trial wheat area, the unit of sampling was fixed at an 18″ square and six such random samples were drawn from each plot of 1/16th of an acre, taking care to omit the bare portions.

Statistical examinations were restricted to the grain yields only.

By this method the coefficient of variability for the whole area showed a substantial reduction from 35·1% to 29·3%.

23. Economics of cotton manuring in the Central Provinces and Berar.

R. J. Kalamkar, Jubbulpore.

Results of the cotton manurial trials at the Government Experimental Farm, Akola, conducted during the quinquennium 1935–40 are analyzed. The following important conclusions emerge:—

(1) The need for the application of nitrogen to increase the outturn is indicated.

(2) The application of potash is not effective.

(3) The application of phosphate in the presence of nitrogen increases the yield significantly.

(4) The application of manure, half at sowing and half at intensive flowering, appears advantageous; but the effect appears to be governed by the amount of rainfall following its application.

(5) It is more advantageous to apply 2/3rd of nitrogen in the form of groundnut cake and 1/3rd in the form of ammonium sulphate instead of giving all the nitrogen in the form of cake.

(6) Cotton does not respond very much to the application of Farm Yard Manure or Compost at the rate of 40 lbs. of nitrogen per acre.

(7) The response to the application of 35 lbs. of nitrogen, either singly as cake or in mixture with ammonium sulphate is proportionately much higher in comparison with the responses secured by the application of smaller doses. The increase in yield is of the order of 59% when 35 lbs. of nitrogen are given, 2/3rd in the form of groundnut cake and 1/3rd in the form of ammonium sulphate.

(8) Application of Farm Yard Manure or Compost either singly or in combination with ammonium sulphate is done at a loss even when cotton prices are of the order of Rs.85 per Khandi of 784 lbs.

(9) Application of ammonium sulphate alone also does not result in statistically significant gain even at higher rates of cotton and a low rate of Rs.4-8 per maund of fertilizer.

(10) Even when cotton sells at Rs.55 it pays to manure it with 35 lbs. of nitrogen, 2/3rd being given in the form of groundnut cake and 1/3rd in the form of ammonium sulphate when groundnut cake sells at Rs.1-8 per maund and ammonium sulphate at Rs.5 per maund, the net profit secured being of the order of Rs.3-6 per acre.

(11) If cotton sells at Rs.75 the profit secured at the above rates of the manures exceeds Rs.8 per acre, the extra investment required being about Rs.9-8 per acre.

(12) Residual effects of the organic manures are noticeable on the subsequent crop of Jowar.

24. On green manuring of sugarcane at Jorhat Farm.

H. N. PAL, Jorhat (Assam).

An investigation with dhaincha, sunnhemp and cowpea at Jorhat Farm for selecting the most suitable crop for green manuring of sugarcane showed that dhaincha was the best so far as yield of plant canes (Co. 361) was concerned. This was followed by sunnhemp and cowpea. Sucrose in juice varied between 19·64%–20·12%, both sunnhemp and control showing slightly better quality of juice than the other two. The residual effects of green manures tested on the first ratoon canes in the following year (1940-41) in the same layout were almost similar. 'Dhaincha' was once again the best in yield of canes showing significant increases over cowpea and control. Sucrose in juice varied between 18·48%–18·84%.

The combined increase over control in tons per acre in plant and first ratoon canes came to 5·49 for dhaincha, 1·76 for sunnhemp and ·29 for cowpea, indicating the superiority of dhaincha. The poor performance of sunnhemp was rather unexpected; it had in previous experiments given much better results showing superiority even to dhaincha. However, experiments are being repeated for confirming the results.

25. A note on the occurrence of the yellow stunted patches of paddy in the Mandalay black cotton soil.

A. T. SEN, Dacca.

Patches ranging in area from 10 sq. ft. to about a fourth of an acre appear every year in the Mandalay black cotton soil, in which paddy plants turn yellow and remain stunted and eventually give a reduced yield. From preliminary experiments of the Mycologist and the Agricultural Chemist, Burma, indication of sulphur deficiency causing the disease was obtained. This has now been confirmed by small-scale plot and water culture experiments. It appears also that the paddy plant in the Mandalay black cotton soil cannot function normally unless the amount of sulphur absorbed by the plant exceeds 0·04%, especially during the early stages of growth.

26. Economics of manuring.

P. V. SUKHATME, New Delhi.

In a recent paper on this subject the author has put forth a statistical and graphical method of dealing with two questions on manuring: (i) 'Does it pay to manure' ? and (2) 'When does manuring cease to pay' ? The latter question is dealt on the assumption that the response curve is a parabola of the second degree. In this paper the response curve has been assumed to be a third degree parabola and of the standard form

$$y = y_0 + D\,(1-10^{-s^{d}})$$

where δ and D are constants, y stands for the yield obtained from dose of manure d and y_0 is the yield when no manure is applied; and their consequences on the analysis of manurial experiments on paddy with groundnut cake worked out.

27. Introduction of early winter paddies from high altitudes for cultivation as Dalua or summer paddies in the plain.

P. D. Dixit, Cuttack.

The number of paddy varieties, cultivated as Dalua or Summer paddy, is very limited on account of the very peculiar conditions in which they grow. These are all coarse paddies giving red rice which is considered unpalatable and indigestible by the middle and upper class people. The number of varieties in winter paddies is unlimited, but most of these do not grow as well as Dalua. The winter paddies have their growing period during hot and humid months with plenty of rainfall, i.e. from June to September; they flower and fruit when the temperature has cooled down. The Dalua paddies grow during cold and dry months, practically without any rainfall, i.e. December to February, and flower and fruit during March and April, when the summer has set in.

The problem was to get a suitable variety for these conditions. On the assumption that early winter paddies cultivated on hill slopes at high altitudes grow with limited supply of water and at low temperature, twenty-one samples of hill paddies were collected from the Agency tracts of Ganjam District. These were grown in Patland of Puri District, along with local Dalua varieties. Some of these paddies gave very good growth. They were as early as the local Dalua, and in some cases the earheads were very long and compact and quality of rice was far superior. Varieties Attunga, Attadhan, Kalifuti, Kodianga, and Sankara appear particularly useful. Over two hundred single plant selections have been made from these paddies for isolation of good yielding strains suited to Dalua conditions. This opens out new fields for search for better varieties for cultivation on Dalua lands.

28. On the vitamin A content of fodders. Part I. The development and distribution of carotene in the plant and the carotene content of some common feeding stuffs.

P. A. Seshan *and* K. C. Sen, Izatnagar.

A study has been made of the development of carotene in plants under artificial as well as field conditions and its distribution in different parts of the plant. The carotene content of some green fodder plants and dry feeds commonly used for stock feeding has been determined.

29. On the vitamin A content of fodders. Part II. Stability of carotene in plant material with special reference to hay making and storage.

P. A. Seshan *and* K. C. Sen, Izatnagar.

A study has been made of the various factors which destroy carotene in plants. It has been found that during hay making and storage, there is a rapid loss of carotene due to atmospheric oxidation and the process is accelerated by heat, light and moisture. Under the prevailing temperature and climatic conditions, hay making is not likely to produce a material rich in vitamin potency.

30. A study of bago-molasses as a feed for cattle.

K. C. Sen, S. C. Ray, *and* S. K. Talapatra, Izatnagar.

Bago-molasses has been prepared by the Imperial Institute of Sugar Technology, Cawnpore, by mixing one part of begasse screenings with two parts of factory cane molasses and a study of its feeding value has been carried out in this laboratory. The material has no digestible protein, but contains a fair amount of carbohydrates and as such it can be used as roughage to a certain extent, thus replacing a part of wheat bhoosa. Owing to its high potash content, it induces diuresis in animals, and as such, an extra amount of salt lick must be used.

31. Tree leaves as cattle fodders.

S. C. Ray, S. A. Momin, *and* K. C. Sen, Izatnagar.

Owing to the scarcity of green fodder in certain seasons and during drought conditions, some trees are extensively lopped for stock feeding. A study has been initiated in this laboratory to investigate the feeding value of some of these leaves and in this paper the seasonal variation in the chemical composition of several leaves in relation to their palatability to cattle is given.

32. Alkali treatment of cereal straws.

K. C. Sen, S. C. Ray, *and* S. K. Talapatra, Izatnagar.

A study has been made of the effect of dilute alkali solution on the lignin encrustation and the composition of wheat, oats and paddy straw. The nutritive value of the treated wheat and paddy straws has been assessed with dairy heifers and it has been found that the treatment significantly increases the starch values of straws. The commercial possibilities of alkali treatment of cereal straws in India have also been discussed.

33. Oxalates in feeding stuffs and their significance in the assimilation of calcium by ruminants. Part I. A method of estimation of oxalic acid in biological materials.

S. K. Talapatra, S. C. Ray, *and* K. C. Sen, Izatnagar.

In the present study a method of estimating oxalates in biological samples has been described. The method is quite different from those in vogue, namely acid extraction or other extraction, which are shown to give low results. It consists in digesting the sample with a strong alkali carbonate solution, which not only breaks up the tissue cells but simultaneously converts, by a process of metathesis, all oxalates into soluble alkali salts. The soluble oxalate is then completely extracted, treated in the cold with hydrochloric acid to precipitate most of the extraneous matter. In an aliquot of the final filtrate, oxalate is precipitated as calcium oxalate by adding calcium chloride solution. Various technical difficulties arise here in connection with the removal of adhering organic matter and details are given of the procedure adopted to get rid of the interfering substances. The oxalic acid is finally estimated by the usual permanganate titration. The method can be used both by macro and micro procedures.

34. Oxalates in feeding stuffs and their significance in the assimilation of calcium by ruminants. Part II. The oxalate content of some fodders and its metabolism in the ruminants.

S. K. Talapatra, S. C. Ray, *and* K. C. Sen, Izatnagar.

Using the method described in Part I, it has been found that oxalates are present in significant amounts in some of the common cultivated fodders and grasses. The oxalates are present both in soluble and insoluble forms. The soluble form represents by far the major portion of the total oxalate. Metabolism experiments conducted with bullocks and cows show that soluble oxalates have no effect on calcium absorption; they seem to be decomposed before entering the stomach proper by some microbial agency in the rumen. On the other hand, the ingested insoluble oxalates are excreted as such without apparently entering into any form of effective metabolism.

35. On the apparent partial failure of cotton in the gang canal colony.

A. Sreenivasan, Indore.

1. The area under cotton as well as the yield per acre in the districts of the Gang Canal Colony (Bikaner State) have been declining during the last few years. The belief is held among the cultivators that the cotton crop is deteriorating and therefore it is not suitable to the tract. This paper reports the results of an enquiry undertaken to investigate the validity or otherwise of this local impression.

2. It is shown that the year to year variations in acre yield are mainly seasonal and are not related with time or with the amounts of rainfall during corresponding periods.

3. A comparative examination of the district soils from *chaks* of good, medium, and poor fertility does not reveal any marked deterioration in the physical properties of the soil. A detailed study of soil from areas affected by black and white *kalar* indicates that *kalar* formation has not proceeded to such an extent as to make reclamation uneconomical.

4. The dissolved salts in the canal waters are not present in injurious concentrations.

5. There has been no deterioration in the yield of cotton grown at the State Farm, the acre yield frequently averaging over twice that in the districts. This fact, together with the results of examination of the soils and the canal waters as also the fact that other *rabi* crops are grown successfully in the canal area, preclude the possibility of bad land being a serious factor affecting cotton failures.

6. It is shown from the results of experiments on farm *vs.* cultivator's method of growing cotton that the prevalent practice of sowing cotton during March-April and the witholding of the first irrigation for 2 to 3 months after sowing are the main factors causing low yields. Best results are obtained by sowing cotton in May-June followed by the first irrigation within one month after sowing. Other necessary improvements in cultural operations are also indicated.

7. The nature of other factors such as Boll-worm attack, bad seed, excessive area under irrigation, dust storms and low prices, responsible in part for the failures, is discussed together with certain remedial measures.

36. Estimation of spinning value of Indian cottons from their fibre-properties.

H. Navkal *and* Nazir Ahmad, Bombay.

The best method of judging the quality of a cotton is by spinning it under standard conditions. Where this is not possible, the spinning value can be estimated from fibre characters, provided the regression equation connecting these with the former is known.

The relationship between yarn strength and fibre properties has been investigated by a number of scientists including Turner and Venkatraman at the Technological Laboratory and in this paper their work has been carried a stage further. It is shown that strains grown in India can be divided into four broad classes (1–4) each having certain characteristic fibre properties. The advantage of having a separate prediction formula for each group is discussed. It is suggested that a breeder while continuing to select for length should bear the following additional points in mind:—

1. Selection work on *inferior* strains (spinning less than 20 counts) should be conducted on the basis not only of a lower fibre-weight per inch but also of a higher

$$\left(\frac{\text{Length}}{\text{diameter or fibre wt. per inch}}\right)$$

   ratio.
2. For *exotic* cottons a low fibre-diameter and a high maturity percentage are desirable.
3. Samples whose fibre-length percentages are very high will not spin as well as expected from their other fibre properties.
4. Some of the *strains peculiar to Gujarat* are very coarse, and their coarseness detracts considerably from their value; consequently attention should be concentrated on improving their fineness as well as their length.

37. Determination of the maturity coefficients for Indian cottons.

R. L. N. Iyengar *and* Nazir Ahmad, Bombay.

The use of the constants derived by Peirce and Lord for the calculation of the maturity coefficient in the case of work done in India is open to two objections: (1) the range of cottons dealt with by them is different, and (2) the method of estimation of fibre maturity is somewhat different from Clegg's method. It is, therefore, necessary that for the Indian cottons the constants have to be determined separately and the present paper deals with the preliminary work so far done on this subject.

The maturity of each fibre is first determined using Gulati and Ahmad's technique. Next the diameter of the swollen fibre, D, and the diameter of the lumen, d, are determined. If the density of the swollen cellulox is assumed to be practically constant inside fibres of all grades of maturity, the expression, $I - \frac{d^2}{D}$, represents the ratio of weight of a fibre to the weight it would have had if it were completely mature. The mean value of this ratio for each maturity gives the corresponding constant. In the six cottons so far examined it is found that the values of these constants are approximately 0·97 for the mature class, 0·80 for the half-mature class and 0·55 for the immature class. The maturity coefficient is, therefore, given by

$$\frac{0{\cdot}97\,M + 0{\cdot}80\,H + 0{\cdot}55\,I}{100}.$$

This expression has been found more suitable for Indian cottons. The fibre weight divided by the present value of the maturity coefficient agrees remarkably with the value obtained from the microscopical dimensions. The figures obtained by using Peirce and Lord's new formula are considerably higher.

From the measurements made in this work the following additional conclusions can also be drawn :—

1. The distribution of the fibre weight per unit length is nearly normal in each maturity class as well as for the whole sample.
2. The fibre weight per cm., calculated from value of D^2-d^2, agrees very well with the observed value.
3. The values of the constants, which can also be derived from the mean fibre weight for each maturity class, are found to agree with those obtained above.
4. The distribution of fibre diameter is normal both within each maturity class and for the whole sample. For each cotton the mean value of the diameter is found to be practically the same for all the three classes.
5. Though the distribution of the wall-thickness is normal in each maturity class, for the whole sample it is heterogeneous.
6. Within each maturity class there appears to be a positive correlation between diameter and wall-thickness. For the whole sample, however, the correlation appears to be negligible on account of the heterogeneous distribution of the wall-thickness.

38. A preliminary note on the changes in the quality of Punjab American 289F/43 with variations in the dates of sowing and with progressive pickings.

S. Rajaraman *and* Mohammad Afzal, Lyallpur.

In a major portion of the Canal Colonies in the Punjab, the general agricultural practice of sowing cotton extends over an interval of about a month, from the 15th May to the 15th June. To study the effect of date of sowing on the quality of lint of P.A. 289F/43, sowings were carried out in 1937, in replicated randomized blocks with seven replications. The dates of sowing were:—

I. 15th April,
II. 5th May,
III. 20th May,
IV. 4th June, and
V. 1st July.

II, III and the IV sowings approximated to the general agricultural practice, I was early and the V late. The lint produced in each of the sowings was tested for fibre characters.

II, III and the IV sowings all yielded lint of the same quality while I (sowing earlier than general agricultural practice) produced lint of a quality definitely inferior to that produced by II, III and the IV sowings. The quality of lint, in pickings from V sowing, was on the whole similar to that of lint in corresponding pickings from the II, III and the IV sowings, even though a lower percentage of mature fibres in the former would detract from the quality of the yarn spun from them.

In normal sowings of P.A. 289F/43, weekly pickings obtained up to the middle of December were uniformly superior in quality to those obtained after that date. Among pickings obtained before the middle of December, those made on the 4th, 11th and the 18th of October possessed on the whole lower mean fibre weight per unit length and lower percentage of mature fibres than the rest, while the mean fibre-length and characters derived therefrom were not significantly different.

39. The effect of differential irrigation on the field behaviour and quality of P.A. 4F.

MOHAMMAD AFZAL (Lyallpur) *and* NAZIR AHMAD (Bombay).

The results of irrigation experiment on Punjab American 4F involving seven different types of irrigation have been discussed. Flowers and bolls produced per plant were not correlated with the quantity of water given to the crop; but, in general, the yield was correlated with watering. Ridging versus flat sowing gave indifferent results.

Application of more water during the growing period is likely to improve, to a small extent, the mean fibre-length of P.A. 4F. The amount of irrigation applied to the crop did not produce any significant effect either on the mean fibre-weight per inch or the standard hair-weight of this cotton. The percentage of mature hairs in P.A. 4F showed a tendency to increase with the amount of water supplied to the crop.

The spinning performance of this cotton showed a small tendency to improve as more water was given to the crop. It is noteworthy, in this connection, that the zamindari system of irrigation and its two variants compared favourably in respect of spinning performance of the lint with the type which represented the highest amount of irrigation.

40. The effects of long-term manurial treatments on the yield of tea and on the composition of the soil.

P. H. CARPENTER * *and* C. J. HARRISON, Toclai (Assam).

1. In a 22-year manurial trial of three organic and two inorganic manures on tea at Borbhetta Experimental Estate (Sibsagar District, Assam), after the first 10 years of application of manures in quantities to supply 30 lbs. nitrogen per acre, the two vegetable organic manures (rape cake and tephrosia loppings) and two inorganics (nitrate of soda and sulphate of ammonia), were maintaining a yield about 40% higher than that of unmanured plots. The animal organic manure (sinews) proved consistently inefficient, raising the yield by only 20% over unmanured tea.

2. No harmful effects due to application of inorganics were apparent after 10 years of application, nor was there any indication of greater cumulative effects of organic manures compared with inorganics.

3. When manurial applications were raised to quantities supplying 80 lbs. nitrogen per acre, the harmful effect of nitrate of soda soon became apparent and crop dropped to the level of unmanured tea. Physical tests on the soil showed that this might partly be ascribed to destruction of its tilth. After 10 years of application, soil acidity was considerably reduced by nitrate of soda.

4. Sulphate of ammonia proved most efficient of all manures tried, and maintained a crop 120% to 200% greater than that of unmanured tea. Marked increase in soil acidity resulted from the continuous use of sulphate of ammonia, accompanied by a greatly improved soil tilth.

5. After 22 years' application of the various manures, the content of nitrogen and organic matter in the soil was significantly higher in the case of sulphate of ammonia and the vegetable organics than the unmanured areas.

6. Animal sinews resulted in no increase in soil nitrogen and a slight increase in soil organic matter, compared with the unmanured soil.

7. Nitrate of soda resulted in only very slight increase in soil nitrogen and organic matter, compared with the unmanured area.

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* Director, The Toclai Experimental Station, Cinnamara (Assam).

8. Except in the case of the animal sinews, manures have not affected the ratio of loss on ignition to nitrogen in the soil. The carbon/nitrogen ratio has been very slightly increased by all manures.

Plant Breeding, Genetics and Cytology

41. A dwarf mutation in winter paddy.

P. D. Dixit, Cuttack.

Occurrence of dwarf forms in paddy culture has been reported by Parnell, Sugimoto, Akemine, Nagai and others.

A dwarf mutation was observed in 1938 in one of our pure types at the Rice Research Station, Cuttack. As its behaviour in subsequent years appeared to be different from that of the dwarf mutations reported before, a short account is given here.

In medium type line culture No. 902-1-5-1-17-7 in a population of thirty-seven plants, six dwarf plants were noticed. The average height of the parent culture (excluding the dwarfs) was 149 cm. while the dwarf plants were only 38 to 35 cm. high.

This culture was breeding pure to type for four years prior to this—the height of plant 7 selected in 1937 of which this culture was the progeny being 143 cm. high. It was considered to be a case of simple segregation, but in subsequent years tall as well as the dwarf plants have been breeding true to type. Tall and dwarf forms are quite similar to one another in morphological characters except that diminution in size has occurred in all parts of the dwarf plants. But the number of tillers per plant in the dwarf is three to four times that in the original parent. Differences in these characters have been studied in detail, and it is proposed to make some crosses in tall and dwarf forms to study their mode of inheritance. These dwarf forms are completely fertile, and no sterility has been noticed as reported in dwarf mutations.

42. An application of the discriminant function for selection in poultry.

V. G. Panse, Indore.

Egg production in poultry is controlled by genetic factors at least partly inherited from the sire. Selection of sires is, therefore, important in ensuring a high productivity of the daughters. A discriminant function score based on different characters of the daughters related to egg production would be the best criterion for this purpose, since the co-efficients of the function are so obtained as to maximize the regression of the genotypic value of the sire on this phenotypic value as reflected in the mean performance of the daughters.

Data on the number of eggs laid, egg weight, body weight of the pullet and her period of maturity were examined for 218 Brown Leghorn pullets belonging to progenies of 17 sires. There were significant differences between progenies in egg weight and period of maturity. Simple correlations in pairs of characters between progenies were not significant; but those for egg number and egg weight with body weight were approximately 0·5. Using the relative values assigned to the different characters by poultry experts, the discriminant function obtained showed that egg weight had the highest selective value while the coefficient for period of maturity was negative as is to be expected. The discriminant function was found to register a higher genetic advance than straight selection on phenotypic values. The application of the analysis of variance for testing the significance of discrimination between sires is discussed.

43. Breeding for resistance to cotton root rot in Gujerat.

G. K. Govande, Baroda.

Cotton root rot (*Macrophomina phaseoli*, (Maubl) Ashby) is prevalent in the *gorat* soils of Gujerat and the present paper deals with breeding investigations in progress to evolve a resistant strain for replacing the susceptible variety, Broach 9 (*Gossypium herbaceum* var *frutescens* H. & G.). Preliminary trials established the partial resistance of a bulk consisting of survivors collected from infested fields from the village Kharkhadi near Baroda. Continuous selection has been done on this material, and families with a mortality of only 20–30% against 95% of Broach 9 are now available. But their spinning value is very low and they are not likely to prove very profitable to the cultivators.

That even repeated selection in the above material has not revealed a progressive improvement for resistance may be attributed to the extreme heterogeneity of the disease in the soil, simultaneous selection for other characters, the dominance of resistant genes and a considerable heterozygosity of Kharkhadi in this respect. Modified progeny row test designs are under test in order to increase the accuracy of progeny comparisons.

Future programme is directed towards combining the resistance of Kharkhadi and of Rozi (*Gossypium arboreum* var *typicum* forma *indica* H. & G.) with the quality of herbaceum strains by hybridization. The crossing behaviour of these types and their botanical relationships are discussed. The need of genetic studies and of rapid methods of testing quality as an aid to breeding is emphasized.

44. A mango seedling with variegated leaf-colour.

S. S. Bhat, Baroda.

This paper records the occurrence of a variegated mango seedling on the Agricultural Experiment Station, Baroda. The variegation in leaf-colour is distinct from signs of malnutrition, and the plant is under further observation.

Crop Physiology

45. Assimilation of atmospheric nitrogen by higher plants.

K. L. Khanna *and* S. C. Sen, Bihar.

In the course of certain investigations on plant metabolism in nutrient deficiency series, it was observed that plants kept in the sun did not suffer from nitrogen deficiency as much as those kept in the dark. Careful experiments were therefore designed to see as to whether or not cane leaves fixed nitrogen when exposed to sun's rays. Gravel sand was sieved through 60 mesh wire gauze and the granular sand retained by sieve was digested with conc. hydrochloric acid (sp. gr. 1·16–1·18) for about 30 hours. This perfectly white sand was thoroughly washed with distilled water, till it was free from acid. It was further treated with formalin and was finally heated in an air oven for 60–70 hours at 120°C. for sterilization. Similarly, the glass bottles selected for planting were sterilized. Material for planting was selected from central nodes after exhaustive experimentation into their nitrogen content. It was found that of the central three nodes the middle portion usually represented the mean value of the two portions on either side. The middle node was selected for planting. It was weighed, treated with chloroform vapour, planted in sterilized bottles containing sterilized sand and watered. exclusively with sterilized redistilled water. The nitrogen content of the other two nodes was estimated at the same time when planting was made, the nitrogen content of the planted portion for experimental purpose being considered equal to either top or bottom node whichever contained a higher percentage. As soon as the plants had germinated, they were divided into two series. The first series was kept exposed to sun's rays for 3·4 hours every morning, while the second series was placed in a dark room with abundant circulation of air. The plants were taken out of the containers at the end of 50–60 days and the total nitrogen determined. The sand of the bottle was also analyzed for nitrogen. The results clearly showed a gain in the nitrogen content of the series exposed to the sun suggesting fixation of nitrogen by sugarcane leaves.

Plant Diseases

46. Control of sugarcane seedling disease and nematode injury.

S. A. RAFAY, S. Y. PADMANABHAN, *and* K. L. KHANNA, Bihar.

In April 1940 and 1941 sugarcane seedlings grown in beds and pans at this Research Station were seen to wither and die. Examination of rootlet, collar and leaf sheath regions revealed the presence of a fungus which yielded *Pythium* sp. in culture. The pathogenicity of the organism thus isolated was tested by artificial inoculations and the organism was recovered. Another symptom in association with the above as well as independently was observed which showed loss of colour in leaves. An examination of rootlets showed numerous nematodes which is the first record of nematodes in the seedlings of sugarcane in India.

The control measures tried to combat the disease and nematode injury consisted of (i) providing sand in the beds to avoid water logging; (ii) bi-weekly treatment of the beds with (*a*) 1 : 10,000 copper sulphate solution; (*b*) Cheshunt Compound; (c) 1 : 10,000 mercuric chloride; (*d*) 1 : 200 formaldehyde solution; (iii) use of soil sterilized at 95°C. for an hour; and (iv) a control set. The best results were obtained with partially sterilized soil (iii) indicating that the causal organism is an inhabitant of soil. Copper sulphate solution and Cheshunt Compound were equally efficacious in controlling the disease while mercuric chloride solution was effective against nematodes.

Statistics and Sampling Technique

47. Sugarcane borers and loss in tonnage in Bihar—a statistical study.

B. R. SEHGAL, L. N. NIGAM, *and* K. L. KHANNA, Bihar.

Previous workers have not taken into consideration the incidence of the borers while calculating the loss in weight due to the attack of pests. In the present paper use has been made of partial regression equation to evaluate loss in weight due to borer attack. The data for this work were afforded by an extensive survey into borer incidence being carried out in the province over the last two seasons. All the partial regression coefficients are negative showing clearly that the incidence of borers tends to produce loss in weight. According to the equations the root borer would produce the greatest damage, top borer would come next and the stem borer last if their incidence were equal. On the basis of actual incidence values observed in the field the order of the loss in weight due to different borers is as follows:—

T, R, S, where T = Top borer, R = Root borer and S = Stem borer.

The actual loss in tonnage worked out to 5–8% for all the borers, and the contribution of the borers was: Top-borer (2·198%), Stem borer (0·303%) and Root borer (0·93%).

48. A statistical study of flower production in cotton.

D. N. Nanda *and* Mohammad Afzal, Lyallpur.

Flowering curves of four varieties of cotton, three American and one *desi,* have been statistically examined. It has been found that the logistic equation used by Prescott did not give a good fit with the observed data. The quadratic form of the same equation

$$\mathrm{Log}\frac{x}{a-x} = Y = A+Bt+Ct^2$$

was employed and it was found to give an almost exact fit.

The relative rate of flower production was found to increase as the season advanced. This was at variance with Prescott's experience in Egypt, where the value of 'K' remained constant throughout the season.

The indigenous variety, 39 Mollisoni, had a higher rate of flower production than the acclimatized Punjab American cottons, while three American varieties did not differ between themselves significantly.

A comparison between the relative rates of growth in height of the main axis and the flower production showed that the higher rate of vegetative growth depressed the rate of flowering.

Marketing and Agricultural Economics

49. Metal polish from limes (a by-product in the lime juice industry).

S. S. Bhat *and* S. G. Bam, Baroda.

The work so far done at the Baroda Fruit Preservation Laboratory shows that about 320 lbs. (14%) of sediment is left as waste per ton of whole lime fruits used in the lime juice bottling industry, and that this sediment, with its high acidity of nearly 6·4%, has commercial possibilities as an effective and cheap metal polish, among other by-products of lime juice, if it is properly packed and distributed for sale.

50. Eco-dairy problem of India.

Dahyabhai H. Jani, Baroda.

Our cattle problem is of Rs 1,500 crores, which may be doubled in a score of years through national planning and co-operative mixed farming, if cattle can be made to act as symbiant of agriculture. Ghee is the only important milk product to fall back upon in a tropical country full of villages and long distances without adequate transportation facilities. The village ghee-making by the churning rod method is obviously defective. Separator machine for separating cream, butter, sour-milk, residuum of ghee (Keeta) was introduced by the writer. Improved method of ghee-making with new stirrers (evaporators) and utensils, centrifuge, temperature control, etc. reclaims (between 8% to 14%) ghee, meeting cost of the separator in the first year of co-operative village dairying.

The quality and quantity of ghee made and reclaimed indicate the desirability of introducing separator method. No butter churn or table worker, etc. are needed. Simple, easy and economical tips for working more profitably village dairy, especially in cow tracts, are given in the paper.

51. Co-operative marketing of milk in Lucknow.

B. MUKHERJEE, Lucknow.

Individual milk marketing: Uneconomic.

Advantages of co-operative method: Processing. Pasteurization. Joint purchase of bulls, fodder and feeds. Better grazing facilities. Cheaper prices. Quick distribution.

Lucknow Milk Union: Its origin: Old marketing methods. Exploitation: Malpractices: Low uncertain prices: False weights: Milk over-evaporated to depress price.

Its objects: To prevent exploitation: Collect and distribute milk quickly: Processing: Pasteurization: Supply of good cattle: Cheap finance.

History: Preliminary cattle census: Approximate yields: Compact areas: Primary milk societies.

Methods: Milking under supervision at common centre: Hygienic methods. Milk register: Member's pass-book: Wells: Milking sheds: Milk assembled at collecting centre: Pasteurization: Flash method heating (160°). Quickly despatched to Lucknow: Cooled down (45°) by electric aerator. Unit cost: Cold storage: Temperature kept constant (45°): Refrigeration: Germs destroyed at high, low and quickly changing temperatures: Lactometer readings: Gerber's test: Chemical sugar test: S.N.F.

Advantages of Milk Union—Better milk: Competitive prices: Prompt regular payments at villages—saving time, expense and efforts. Higher milk prices to members: Distant marketing problems simplified: Honest dealings. No fraud: Correct weights: Hygienic milking methods: House delivery: Better bulls supplied. Herd Books. Wells: Milking sheds: Increased employment: Recovery of overdues. Arbitration in disputes and litigation.

Administration—Board of Directors: Milk handled: Butter and ghee production. Wide circle of customers. Primary societies. Total sales: Milk prices paid. Causes of losses—largely recovered.

Government aid.

Marketing reorganization on co-operative lines improves and stabilizes industry.

52. The co-operative marketing of rice in the United Provinces.

B. MUKHERJEE, Lucknow.

Problems of agricultural marketing: Large leakage in income through disorderly marketing.

Co-operative marketing offers best solution: Actual illustration: Dehra Co-operative Rice Marketing Society.

Dehra produces best Indian table-rice. But market ruined by adulteration and malpractices. Co-operative society formed to stabilize industry.

Its origin: Objects—to safeguard interests of producers and consumers: Prevent adulteration and malpractices: Eliminate middlemen: Lower prices: Give consumers purer quality and producers fair price: Give members cheaper finance and improve marketing facilities.

Its methods and organization: Share capital: Rate of advances: Liquid cover for advances: Sureties: Certified godowns: Commission on sale: Distribution of profits.

To prevent adulteration members shall not handle other rice: must sell exclusively through society. Penalties.

Its advantages: It stopped cheap adulteration: Rice graded under 'Agmark' by Agricultural Marketing Adviser: Lost markets recovered: Facilities of supply increased: New agencies: New markets created—from Quetta to Coorg, from Karachi to Burma: It eliminated middlemen:

Stopped leakage: Increased cultivator's incomes: Prices secured Re.1 per maund higher: Yet consumers get better quality at cheaper prices. It prevented disorderly marketing: Provided cheap finance to cultivators: Saved time, effort and expenses of individual marketing: Correct weights: Saves unauthorized tolls and terminal charges.

Its present position and prospects: Quantity of rice handled and sold: Membership: Working capital: Profits: Storage godowns: Reserve Fund: Loyalty of members.

A model for other provinces and States.

Agricultural Meteorology

53. Preliminary studies on the upward movement of water and salt solutions through soil columns.

L. A. Ramdas *and* A. K. Mallik, Poona.

The ascent of water and salt solutions in soil columns has been studied with the help of glass tubes filled with soil. The importance of packing the soil in the tube, in experiments of this nature, has been stressed and the standard method of packing followed is described. To eliminate further the error due to packing the experiments were done on replicated basis. The upward movement of water and 2% solutions of some sodium salts have been tried with three typical Indian soils, viz. (1) the black cotton soil of Poona, (2) the red soil of Bangalore, and (3) the sandy soil of Trivandrum and it has been found out that the ascent of the sodium carbonate solution is very strikingly slow in the black cotton soil of Poona. The results obtained in another interesting experiment investigating the upward movement of water in mixtures of Poona soil and sand, in different proportions, are also discussed.

54. Crop weather studies on 'Rabi' Jowar, 1940-41. (Sorghum winter crop.)

A. K. Mallik *and* P. S. Srinivasan, Poona.

The paper deals with the simultaneously recorded data of the growth of the crop by the sampling method and the meteorological conditions inside the growing crop. The sampling method is described and the sampling error obtained on the different days of observation is given. Accumulated values of temperature, vapour pressure and relative humidity of the air inside the crop are given, and the relationships between the growth in height of the crop and the temperature and relative humidity inside the growing crop has been studied with the help of suitable curves.

55. Date of establishment of the south-west monsoon on the west coast of India and its prediction by statistical methods.

L. A. Ramdas *and* S. Gopal Rao, Poona.

An attempt has been made to predict the date of onset of the S.W. monsoon along the west coast of the Indian Peninsula using statistical methods. The factors used are (1) April rain in Seychelles, (2) the date of equalization of pressure over Lahore and Bangalore, and (3) April rain in S. Rhodesia. A regression equation is worked out using data for the years 1899 to 1939.

56. Is there a periodicity in the annual rainfall at Chaibassa and some neighbouring stations in N.E. India ?

S. Gopal Rao *and* P. V. Pimpalwadkar, Poona.

The question whether any periodicity exists in the rainfall of Chaibassa or of any neighbouring station or stations is examined. The rainfall of eleven stations including that of Chaibassa is analyzed using the method of periodogram analysis in which trial periods ranging from three to twelve years in the case of Chaibassa and three to seven years in the case of others are taken. To see if the four-year periodicity shown by Chaibassa rainfall is likely to occur by pure chance, sixty-one trials of four-year periods are made, the rainfall figures being selected at random. The method of analysis of variance is used to test the significance of the four-year period. The evidence for periodicity is not quite conclusive.

57. The evaporating power of the air layers near the ground in different environments.

P. K. Raman, Poona.

The paper summarizes the observations of evaporation in the open and inside different crops taken with Piche evaporimeters. The variation of the evaporative power of the air inside the various crops is dependent on the density of plant population, i.e. the wind-break effect of a crop, as well as on the humidity conditions inside it. The latter factor is influenced by transpiration and evaporation from the soil. Irrigation exercises a great control on humidity.

The evaporation generally increases with height above ground. The mean values are highest in the open, and decrease in the order given below:—

	Evaporation as per cent of the open at corresponding level.		
	4 ft.	2 ft.	1 ft.
Rabi jowar	62	43	37
Double beans	41	27	25
Sugarcane	34	30	27
Betel vine	25	21	20
Actual evaporation in the open in inches	0·382	0·423	0·392

General

58. Preservation of the Baisakhi Palas (*Butea frondosa*) brood of the lac insect.

P. S. Negi, Namkum.

Palas (*Butea frondosa*) is the largest host cultivated for lac in India. But major part of the Baisakhi (October to June-July) crop has to be cut *Arhi* (immature) from it from middle of April to middle of May. The chief reasons for cutting the crop *Arhi* are that Palas, due to leaf fall, is practically naked in the first half of the summer season. Therefore, in hot districts, most of the female lac insects die on it due to atmospheric draught and low biological activity of the host. The result is that (i) the cultivator gets only about half the quantity of lac than he would get, if the insects survived in normal numbers till maturity as they do in the Katki crop when such adverse conditions are absent; (ii) there is scarcity of brood lac to infect the next crop giving rise to an extremely disproportionate distribution of trees to cultivate *Katki* and *Baisakhi* crops.

To obviate the above conditions, three-fourths of the leaves with their long stalks was removed from 100 trees in October 1940 and infected with lac, another 100 comparable trees without any treatment were infected as control. This resulted in an economy of brood lac to the extent of over a maund. By the end of March 20% experimental trees had put forth new leaves against 4% of the control. Also at crop maturity due to severe summer, the control trees did not yield any brood lac but the experimental trees, in spite of severe summer, yielded one maund twenty-three seers and eight chattacks of brood lac.

59. Cold storage experiments with potatoes.

G. S. KULKARNI, Gwalior.

Potato is one of the intensively cultivated garden crops in the Gwalior State. It covers an area of 2,075 *bighas*. Its cultivation is chiefly centred in the Gird, Morena and Bhind Districts which occupy more than 3/4ths of the area under crop grown in the Gwalior State. The grower does not preserve his seed, but purchases it from the merchants who import it from places outside the State. Calculating the seed rate at 5 maunds per *bigha*, the total quantity of tubers thus imported comes to about 10,375 maunds. The price of seed tubers at the planting time varies from 8 to 10 rupees per maund. At an average rate of Rs.9 per maund the total money value of the seed tubers comes to Rs.93,375. Thus, roughly a lakh of rupees worth seed is imported. This drain from the State every year could certainly be prevented if arrangements for seed storage were undertaken.

The last crop of potato is taken at the end of March and the first crop is planted at the end of October. The tubers are thus to be stored for 6 to 7 months.

Potato storage is one of the difficult problems the grower has to contend with. It requires a special technique entailing constant care and alertness. It is not practised by the individual cultivator, but is done by some of the big growers or by middle men who make a business out of it. Generally the tubers are stored in cool places in underground pits or in thatched huts. Every now and then the tubers are sorted out to remove the spoiled ones. This goes on during the whole period of 6 to 7 months. The spoiling of potatoes is due to rotting caused by the high temperature experienced during the whole period of storage, which induces bacterial and fungus diseases, which are again often aggravated by the attacks of potato moth. Notwithstanding constant care and sorting considerable quantities of tubers—often half to three-fourths—are lost. This heavy waste consequently increases the price of tubers from Rs.1-4-0 at harvest time to Rs.8 to 10 at planting time. The potato seed storage is thus a sort of gamble, and consequently it is beyond the reach of an ordinary grower. He has neither the time nor the money to invest in this risky business. He, therefore, is required to purchase his seed at such a high price.

The only remedy for eliminating completely this heavy wastage is to store the potatoes at a low temperature produced by refrigeration. The Imperial Council of Agricultural Research has been financing the work on the cold storage of potatoes at Poona, under its Cold Storage Research Scheme. The work has been completed and the results will be shortly published. These results show that potatoes keep well even for a year at 35°F. and for about 6 months at 40°F. There is no appreciable waste at either of these temperatures. Potatoes sprout within a short time at temperatures higher than 40°F.

To confirm the Poona results, trials on a small scale have been begun by the Mycological section of the Gwalior Agricultural Department. Potatoes have been stored in refrigerator the temperature of which ranges between 35 and 40°F. So far no wastage due to the rots has been found but there has been some sprouting.

60. Effect of calcium on rennet coagulation of milk.

V. JAGANNADHAN *and* M. S. RAMASWAMI, Bangalore.

Calcium (Ca^{++}) by itself has a slight inhibitive action on rennin, but if previously added to milk, it catalyzes the clotting very considerably.

Dried whole milk, as obtained from abroad, requires very little addition of calcium; but the average Indian milk (cow or buffalo) seems to require at least a slight supplement of calcium, in fact, some of the samples do not clot at all unless 0·1% of calcium (as chloride, lactate or gluconate) is added.

The effect of calcium increases with concentration up to 0·6% (seven-fold), but such a high concentration may not be needed or even desirable in practice. A safe concentration would be 0·05 to 0·1% and this not only reduces the time required for clotting (to about a third) but also saves in rennet. The effect is seen in the case of fresh, pasteurized or boiled milk.

Addition of small quantities of lactic acid, either by itself or in addition to calcium, is not so favourable to clotting as is generally reported. In some cases, it actually depresses the effect of calcium.

The significance of the above observations in relation to digestive processes, as also the utilization of rennet for household purposes and in industrial operations like the manufacture of cheese and casein need hardly be elaborated.

SECTION OF PHYSIOLOGY

President:—B. T. KRISHNAN, B.A., M.B.B.S., M.Sc.

Experimental Physiology

1. Action of K and Ca on the central nervous system.

B. B. DIKSHIT, Bombay.

The action of K and Ca on the central nervous system was studied in cats and dogs under chloraloso anaesthesia, by introducing aqueous solutions of KCl and $CaCl_2$ into the ventricular system of the brain. The salts were used in strengths varying from 0·1 to 1·0%. A cannula was fixed into the right lateral ventricle and another into the cisterna magna and the solution was allowed to flow through the ventricular system at a constant rate and pressure. It was found that KCl markedly stimulated the sympathetic centres in the mid brain, preceded by a slight stimulation of the vagus centre. Thus introduction of a KCl solution into the brain ventricles produced a slight depression in the blood pressure followed by a marked rise, dimunition in the volumes of intra-abdominal organs, dilatation of the bronchioles and relaxation of the small intestines. The initial vasomotor depression was abolished by atropine. $CaCl_2$ solutions produced the opposite effects.

2. The effects of paratharmone on intestinal movements and the physiological basis for the treatment of piles with desiccated parathyroids.

K. VENKATACHALAM, Madras.

A study of the action of paratharmone and calcium salts on the movements of the jejunum, ileum, caecum and colon showed consistently a marked stimulating effect. It was inferred from this observation that the occurrence of piles might be due to a lack of intestinal tone consequent on some derangement in the calcium metabolism, and consequent strain exerted by a person during defecation leading to an abnormal pressure on and the ultimate rupture of the veins of the rectum.

Corroboration of this view has been forthcoming from encouraging clinical results obtained from several cases of piles treated with paratharmone or desiccated parathyroids. The quantity of the drug required for arresting the distressing symptoms of the disease varies from individual to individual; some require only 4-5 tablets of 1/10 grain each of desiccated parathyroid for improvement while others need 12 tablets or more. Occasional use of the medicament thereafter prevents recurrence of the ailment.

3. Observations regarding the influence of vitamins B_1 and C on the effects of adrenaline on a strip of intestine of rabbit in calcium deficient, normal, calcium excess and potassium deficient Ringer.

N. M. BASU *and* G. K. RAY, Calcutta.

The experiments were performed by Dale's method. The following results were obtained:—

(A) In normal and calcium deficient Ringer Solution vitamin B_1 (10γ in a bath of 200 c.c.) tends to neutralize the effect of adrenaline (1 drop of 1:100,000 to the same bath).

(B) If calcium be present in excess in Ringer Solution, the above-noted effect of B_1 was not observed.

(C) The addition of 10 mg. % of vitamin C to the normal Ringer did not produce any effect on the contractions, but when added to calcium deficient Ringer the contractions were increased in amplitude. Vitamin B_1 did not affect the action of vitamin C.

(D) In potassium deficient Ringer vitamin C (10 mg. %) had a slight stimulating effect on the contractions, but when added with vitamin B_1 (10γ in 200 c.c.) there is marked inhibition of contractions. On the addition of 1 drop adrenaline (1 : 100,000) to the same bath the inhibiting effect of vitamin B_1 was neutralized and slight augmentation was noticed. Vitamin B_1 alone had no effect on the contractions.

Haematology

4. A study of haematological standards of South Indian students.

J. K. Lucas, Madras.

A study of blood counts (R.B.C., W.B.C. Total and differential) and haemoglobin content was made on 140 healthy male medical students between the ages of 18 and 28 at the Central Institute of Physiology, Madras.

The average R.B.C. count was 5·39 millions per cubic millimetre which is slightly lower than the English (Price-Jones, 5·42 mills.) and the American standards (5·5 mills.). The minimum was 4·2 mills. and maximum 6·87 mills., per c.mm.

The W.B.C. count varied from 5,000 to 11,800 and had a mean value of 7,845 which is lower than the average given for westerners. These values obtained are slightly higher than those reported by Napier and Das Gupta for Bengalis and Rahman and Zaidi for the people of Hyderabad. As regards the differential W.B.C. count, it was observed that the number of neutrophils was lower than the normal figures according to the western standards, while the number of lymphocytes, eosinophils and monocytes was definitely higher.

The mean haemoglobin content was 14·57 gm. per 100 c.c. of blood which is slightly lower than what was reported by Sokhey (Bombay) and Napier and Das Gupta (Bengal). Compared with the western standards the figure obtained here is higher than that for Europeans but lower than that for Americans.

5. Blood study in normal cattle.

D. N. Mullick *and* A. K. Pal, Izatnagar.

Observations were recorded on some blood constituents in young and adult animals of different ages, sexes, and physiological conditions at Imperial Veterinary Research Institute farm, Izatnagar. The blood was analyzed for Haemoglobin, Iron, Calcium, Magnesium, Inorganic, Phosphorus and Sugar. Standard methods were employed.

Preliminary study showed that the young animals had higher values in almost all constituents. The adult dry, pregnant and lactating groups showed practically no difference.

Three different breeds were examined, but as the number of animals in each breed was not large, no definite conclusion in regard to any breed difference could be drawn.

6. Plasma trypsin and prothrombin.*

N. K. Iyengar *and* K. B. Sehra, Calcutta.

Prothrombin is a protein associated with the globulin fraction of plasma. It is so labile that even a slight change might bring its inactivation. The trypsin in plasma, though present in small quantities, is capable of inactivating prothrombin, if the plasma is incubated for four to six hours. The destruction of prothrombin is followed by the determination of 'prothrombin times' before and after incubation. It is found that during this short period of incubation, there is a negligible increase in non-protein nitrogen of the plasma. This indicates that the small amount of trypsin present in plasma, acting at a *p*H of 7·2 (slightly removed from the *p*H optimum for trypsin), is not capable of breaking down the prothrombin protein in such a short period, but brings about only the disaggregation of the protein. This disaggregation without disintegration appears to be sufficient for the gradual inactivation of prothrombin. It is intended to throw some light on the nature of prothrombin by extending work along these lines.

7. Free plasma trypsin in normal and various pathological conditions.*

N. K. Iyengar, K. B. Sehra *and* B. Mukerji, Calcutta.

It is generally recognized that certain pathological conditions influence the protein metabolism and such changes would naturally tend to be reflected in the proteolytic system of blood. In pursuance of this idea, the trypsin content of plasma in normal and various pathological conditions has been estimated. Significant results have been obtained in certain cases of Anemia and Thrombocytopenic Purpura. The significance of these findings are discussed.

The rôle of this trypsin in the destruction of Insulin in blood has been discussed by Iyengar and Scott (*Tran. Roy. Soc. Canada*, 1940). The plasma from an interesting case of Schizophrenia, who was highly resistant to Insulin, was found to have the same trypsin content as in a normal subject. The plasma trypsin content was found to be normal in a number of diabetic subjects. The rate of *in vitro* destruction of Insulin by the plasma of these diabetic subjects was also found to be similar to that of normal plasma. Hence the enzymic destruction of Insulin in the circulating plasma probably plays a minor rôle in accounting for the quick disappearance of Insulin either in diabetic subjects normally reacting to Insulin or in schizophrenic and diabetic subjects highly resistant to Insulin.

8. *In vivo* action of certain drugs on the tryptic activity of plasma.*

N. K. Iyengar, N. K. Dutta *and* B. Mukerji, Calcutta.

It has been reported by Chopra and his collaborators that the clotting time of blood of a monkey is accelerated by the injection of small doses of cobra venom and inhibited if the dose of the venom exceeds a particular limit. In view of the generally recognized rôle played by trypsin in the process of coagulation, it occurred to the authors that *in vivo* changes in free plasma trypsin might be brought about by the injection of cobra venom. The results obtained by our experiments conducted on a dog show that a three- to four-fold increase of free trypsin in plasma takes

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* Carried out in the Biochemical Standardization Laboratory (Govt. of India), All-India Institute of Hygiene and Public Health, Calcutta.

place. The mechanism of such a remarkable rise in plasma trypsin and its significance in the therapeutic applications of cobra venom are discussed. The influence of other drugs, like vitamin K, vitamin C, etc., which are associated with the prevention of haemorrhagic syndromes, on free plasma trypsin, is also reported.

9. Trypsin-kinase in blood.*

N. K. Iyengar, Calcutta.

From experimental data, a picture of the proteolytic system existing in blood has been presented, and the possibility of the presence of a trypsin-kinase in blood has been discussed. The red blood cells and the platelets have been examined for the presence of trypsin-kinase, and it has been shown that the R.B.C. do not contain the kinase.

Experiments reported in this paper strongly suggest the presence of trypsin-kinase in the platelets, which are capable of liberating the trypsin from the 'inhibitor-compound' present in acetone-precipitated plasma proteins.

Biochemistry and Nutrition

10. Observations on certain features of dietetic habits and nutritional state of an aboriginal (Ho) tribe.†

K. Mitra, Patna.

A dietary survey of 250 Ho (aboriginals in Singhbhum District) families consisting of 1,273 persons were carried out from November to April. The families were divided into four groups on the basis of average annual income per consumption unit. 64% of the families in Group I, 46% in Group II, 35% in Group III and 3% in Group IV were found to consume diets quantitatively deficient. The intake of calories, protein and fats were found to maintain a positive correlation with the rise in income level, not so the other protective foods. Though the people entertain no prejudice against flesh foods very little was actually consumed. The most notable feature was that 88% of the families used no fats for cooking purposes. A little more than 2,400 children were also examined clinically and by naked eye rating about 32% of the children were found to be poorly nourished whereas by Kundson-Schiotz index about 27% were declared to exist in a state of malnutrition. It has been definitely proved that rise in income is not always associated with an improvement in the diet; ignorance and traditional dietary habit being responsible to a certain extent. Poverty is responsible for quantitative deficiency or shortage of calories.

11. Estimation of food value of another batch of edibles consumed in Bihar.†

K. Mitra *and* H. C. Mittra, Patna.

Three kinds of grain foods, four kinds of flesh foods, seventeen kinds of fruits, twenty-eight kinds of leafy vegetables, thirteen kinds of other vegetables, four kinds of milk preparations and three kinds of miscellaneous

* Carried out in the Biochemical Standardization Laboratory (Govt. of India), All-India Institute of Hygiene and Public Health, Calcutta.

† Carried out under the auspices of the Nutrition Scheme, Public Health Laboratories, Bankipur, Patna.

foods have been analyzed chemically. *Ghonghi* or meat of small snail was found to be particularly rich source of calcium. The seeds of *lama* (Bauhinia vahlii) were found to be unusually rich in fat. The calcium content of 19 kinds of *sag* (edible green leaves) analyzed varied between 55 mg. to 515 mg. per 100 gm. In the group of milks that of buffalo was found to be the richest followed by cow and goat in order of richness in protein and fat content.

12. Comparative study of the nutritive value of milk proteins. Part I. By rat growth method.*

K. MITRA *and* H. C. MITTRA, Patna.

A comparative study of the nutritive qualities of protein present in the whole milk of cow and that of goat was carried out by rat growth experiment on the lines suggested by Osborne, Mendel and Ferry. The feeding experiments were carried out at 15 and 10% levels of protein intake in the case of each kind of milks. Groups of six laboratory bred white rats were grown for a period of eight weeks and at the end of the period the biological value for cow's milk was found to be 1·53 and 1·73 and that for goat's milk 0·76 and 1·04 at 15 and 10% levels of protein intake respectively. The results were tested statistically and the differences proving the superiority of cows milk over that of goat in growth promoting properties and the favourable results at 10% level of protein intake as compared to 15% level were found to be significant.

13. The growth-promoting value of eggs.

A. J. MACDONALD *and* S. BOSE, Izatnagar.

A series of four nutritional experiments with young rats were carried out to investigate the value of egg and soya-bean supplements to a typical Bengali village diet. The Bengali diet only and the Bengali diet supplemented with 0·5% egg-shell gave a very poor rate of growth and unsatisfactory health. On the other hand, supplements of eggs to the Bengali diet proved very beneficial in promoting growth and general health. However, the Bengali diet plus eggs, proved inferior to the same diet plus eggs plus 0·5% egg-shell. The addition of soya-beans to the Bengali diet was also beneficial but the results were markedly inferior to those obtained with the Bengali diet plus eggs. Partial replacement of the soya-beans with eggs gave considerably better results than soya-beans as the sole supplement. No beneficial effect was obtained by adding supplements of egg-shell to any of the rations containing soya-beans. From the nutritional and economic aspect a Bengali diet in conjunction with a daily supplement of 1·2 eggs and 66 gm. soya-beans appeared satisfactory for children 6-9 years of age.

14. Proteins of fish eggs.

M. DAMODARAN *and* K. RAMAMURTI, Madras.

From the egg yolk of *Arius jella* two proteins have been isolated both containing phosphorus. The major constituent is a typical ichthulin which can be precipitated from the yolk by simple dilution with ice cold water and is obtained in yields of about 25 g. per 100 g. of yolk. The

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* Carried out under the auspices of the Nutrition Scheme, Public Health Laboratories, Bankipur, Patna.

second protein (10 g. per 100 g. of yolk) has the property of an albumin in contrast to the pseudoglobulin isolated from Selachian eggs by Needham. The two proteins have been purified by the usual methods and analyzed for their content in the biologically important amino-acids. The opportunity has been utilized for making a comparative study of some of the more recent methods for the determination of amino-acids.

15. Studies on neuro-proteins.

NRIPENDRA LAL LAHIRY, Bangalore.

In recent years the neuro-proteins have attracted much attention owing to the fact that they are made up of an enzymic decomposable part of the type of the collagens and the enzyme resistant part known as the neuro-keratins. Block (*J. Biol. Chem.*, **121**, 761, (1937)) has isolated Neuro-keratin I and Neuro-keratin II from the water-soluble and the whole brain proteins. The water-soluble brain protein (beef) has been prepared according to Block (*loc. cit.*) and was found to contain 2·05% phosphorus. In view of the high percentage of phosphorus, the mode of linkage of phosphorus in the protein molecule has attracted our attention and the protein has been subjected to the action of pepsin, trypsin, 1% sodium hydroxide and kidney phosphatase. The results of these experiments clearly indicate that the phosphorus is firmly bound to the protein molecule and not split off either by kidney phosphatase or 1% alkali. Further work is in progress, the details of which will be published elsewhere.

16. Vitamin A potency of cow's milk in relation to heavy carotene ingestion.

K. C. SEN *and* B. C. RAI SARKAR, Izatnagar.

An ingestion of one to two million international units of vitamin A in terms of carotene in green grass has given a value of about 10,000 International Units per pound of butter in the milk of Hariana cows under stall feeding conditions. When animals were allowed to graze, this value occasionally reached a figure of 12,000 units. Carotene contributes about 25% of the total potency. Metabolism experiments show that with low intake of carotene the balance is negative, but this becomes positive with an intake of one gram per day. The percentage of ingested carotene excreted in milk is extremely low, showing a huge wastage of food carotene.

17. Studies in vitamin A metabolism. I. Effect of the inclusion of coconut cake in the basal diet.

G. B. RAMASARMA, Bangalore.

The effect of the inclusion of coconut cake in the basal diet of experimental rats on the absorption and utilization of carotene administered to them was studied. Using purified Polson's casein, no confirmation could be obtained for the claims made by Wilkinson and co-workers on the presence in the coconut cake of a factor essential for the absorption and utilization of carotene and vitamin A. The animals receiving the basal diet containing coconut cake excreted as much of the administered carotene as the controls did; they showed far inferior growth responses and possessed much less of vitamin A reserves in their livers at the end of the experimental period. Statistical examination of the results showed that the inclusion of coconut cake has made the basal diet altogether unsuitable for vitamin A studies.

18. Studies in vitamin A metabolism. II. Absorption of carotene at minimal doses.

G. B. Ramasarma *and* D. N. Hakim, Bangalore.

Wide discrepancies between the theoretically expected and experimentally obtained potencies of vitamin A, as compared to the standard β-carotene, have led to a considerable amount of speculation on the manner of conversion of carotene into vitamin A in the physiological system. It has been suggested that the theory and experiment can be reconciled if we assume an unsymmetrical fission, that is, alternately on either side of the 15-15′ carbon linkage as the first step in the conversion (Morton, *Chem. & Ind.*, 1940, **59**, 301; Edwards, *Analyst*, 1940, **65**, 280).

With a view to throw some light on the absorption of carotene at test dose levels, studies were undertaken on experimental rats which were depleted of their vitamin A reserves. It was observed that even on a basal diet, devoid of any vitamin A or carotenoid pigments, the rats excreted approximately 0·25 microgram-equivalent of a pigment which would be estimated as carotene by the ordinary methods of analysis. Spectrophotometric examination, however, revealed that the pigment had no absorption maxima but showed only a general absorption. On a supplement of one microgram of β-carotene per rat per day, the animals were found to excrete about 15% of the ingested carotene, as calculated from the blank and the apparent carotene content of the faeces of the experimental rats. By subjecting the unsaponifiable extract to chromatographic adsorption analysis on a column of Brockmann's alumina, the true carotene was separated from the non-carotene pigment and its identity was established by spectrophotometric data. Similar results were obtained in the case of animals receiving a supplement of two micrograms of β-carotene per rat per day. It is suggested that the incomplete absorption of the standard β-carotene as demonstrated in these experiments together with the possible destruction of a part of the ingested carotene might be responsible for the discrepancies and that there is no need to revise the theory of symmetrical fission of a molecule of the β-carotene giving rise to two of vitamin A.

19. A study on the effect of execessive doses of ascorbic acid on the urinary excretion of free, dehydro and combined ascorbic acids in various animals and human subjects.

Sachchidananda Banerjee, Calcutta.

Urine contains besides ascorbic acid in the free form, dehydroascorbic acid and combined ascorbic acid. Excretion of combined ascorbic acid is relatively increased in patients suffering from pulmonary tuberculosis and in ascorbutic and infected guinea-pigs. Effect of prolonged ingestion or injection of excessive doses of ascorbic acid on the urinary excretion of free, dehydro and combined ascorbic acid has been studied in guinea-pigs, rats, rabbits, normal adult human beings and patients suffering from acute pulmonary tuberculosis. In all the conditions studied the combined ascorbic acid disappears from the urine within varying periods. It has been suggested that in the absence of ascorbic acid the normal metabolism of the food-stuffs and of tissue-constituents may be disturbed and the intermediary products may accumulate, which may be excreted in combination with ascorbic acid. When large doses are fed the metabolism is complete and intermediate products do not accumulate and therefore the excretion of ascorbic acid in combination with these products would tend to diminish. This may happen both in normal and infected conditions, and the quicker disappearance of combined ascorbic acid from urine of normal persons by feeding ascorbic acid may be related to the possibly greater speed in the action of vitamin C in normal individuals.

20. The intradermal test as an index of ascorbic acid nutrition. The relation between the intradermal test time and the ascorbic acid content of livers of guinea-pigs.

SACHCHIDANANDA BANERJEE, Calcutta.

It has been observed previously that a minimum time of min. 20–30 secs. in the intradermal vitamin C test is obtained both in guinea-pigs and in human beings after administration of massive doses of ascorbic acid. When this minimum time in the skin test is reached we consider that the skin is saturated. It was of interest, however, to investigate whether other organs of the body are also saturated when the skin is saturated. In otherwords, whether saturation of the skin is an index of saturation of the whole body. Three groups of guinea-pigs were respectively placed on scorbutic diet, normal diet and normal diet with supplement of vitamin C for about three weeks. After this period the animals of different groups were killed and ascorbic acid content of liver estimated. Prior to killing twenty-four hours' urinary excretion of ascorbic acid and the intradermal test time were determined. Ascorbic acid content of the liver is greatly diminished in guinea-pigs on a scorbutic diet, 2·66–3·13 mg. per 100 g. of liver. The urinary excretion of free ascorbic acid per animal per day is 0·05 mg. The intradermal test time is highest in this group of guinea-pigs, 4 min. 30 secs.–9 min. 15 secs. In guinea-pigs on normal diet free ascorbic acid content of liver varies from 6·30–27·19 mg. Urinary excretion of ascorbic acid in this group is 0·58 mg. The intradermal test time varied between 2 min. 30 secs. and 5 min. There is little variation in the ascorbic acid content of the liver of animals getting a supplement of ascorbic acid (18·22–31·27 mg.). The daily urinary excretion of ascorbic acid is highest in this group (33·82 mg.). The intradermal test time is 1 min. 30 secs. in all the animals. The intradermal test may, therefore, be taken as an additional index for the assessment of ascorbic acid nutrition of the body.

21. Vitamin 'C' adequacy in South Indian diet.

A. SITARAMAMURTI, Madras.

An investigation into the dietary habits amongst a mixed group of 120 students of the Madras Medical College, shows that the South Indian diet contains an adequate amount of vitamin 'C'.

Since it is known that latent conditions of vitamin 'C' deficiency without obvious symptoms can occur, this investigation was carried out with a view to detect such deficiency.

Capillary fragility test based on Gothlin's principle was adopted throughout this investigation.

The results obtained by me show that 93% of the students developed subcutaneous haemorrhages ranging from 0 to 3 in a circular area of 6 cms. diameter over the ante-cubital fossa and this may be taken as an average index in normals.

Regarding the Nordic races, Gothlin is of opinion that anything over eight petechiae is indicative of vitamin 'C' deficiency. If this standard is accepted, the South Indian diet may be said to contain an adequate amount of vitamin 'C'.

22. Studies in insect nutrition. Part II. The nature of the fat soluble factor.

P. S. SARMA *and* M. SREENIVASAYA, Bangalore.

Experiments on the nutrition of the rice moth showed that the insect requires two groups of the essential growth factors: (1) the watersoluble and (2) the fat soluble. This paper relates to the concentration of the fat soluble factor from Jowar and describes the method of purification and the biological assay of the active fractions. The factor has been found to be associated, if not identical with, one of the sterols of Jowar.

23. Investigations on endogenous nitrogen metabolism in bullocks.

N. D. KEHAR, R. MUKHERJEE, *and* K. C. SEN, Izatnagar.

The endogenous urinary nitrogen of an animal gives a measure of its protein requirement for maintenance and forms the foundation on which are based the protein requirements for growth, lactation and other functions. This value is also necessary in estimating the biological value of feed protein by the Thomas-Mitchell method. Considerable amount of works has been done on these aspects of protein metabolism in non-ruminants. It has been found very difficult in the case of cattle to devise and prepare a 'N-free, energy-adequate diet' that will be eaten by the animals in sufficient quantity for a desired period. This explains why no experimental data appeared to be available up to 1929 on this point (Mitchell, 1929). So far as our information goes, this position has not changed during the last decade.

It has been possible for us to devise and feed bullocks on a diet containing as low as ·02% nitrogen and this enabled us to study their endogenous nitrogen metabolism. The endogenous nitrogen excretion was found, in the case of U.P. hybrid bullocks to be about ·02 gm. per kg. body weight, the lowest figure so far recorded (in experiments in which nitrogen-low diet was fed) being ·03 gm. per kg. The creatinine N in urine expressed as per cent of total urinary endogenous nitrogen was about 34. Negligible amounts of urea was present in the urine when endogenous state is reached.

24. A semi-micro method for estimating allantoin and its excretion in the urine of farm animals.

S. C. RAY, Izatnagar.

A rapid semi-micro method of estimating allantoin in the urine of farm animals has been described. The allantoin-N content in the urine of cows, goats and sheep under normal condition of feeding and management has been found to be 10·4%, 7·8% and 10·4% of the total urinary-N. Unlike the findings of other workers, the present investigation shows that the distribution of allantoin-N as a percentage of total purin-N, is practically the same for the three species of ruminants, namely, cows, goats and sheep.

25. Phosphatase in faeces.

S. C. RAY, Izatnagar.

A method of measuring the activity of phosphatase in faeces has been described. A preliminary study of the faecal phosphatase excretion in goats during normal metabolism and during a prolonged fast show that under normal conditions, animals excrete a significant amount of this enzyme in their faeces but that this excretion is considerably reduced during the fast.

26. Variations of carotene, vitamin C, total acid, *p*H and the sugar contents of different varieties of mangoes in the course of their ripening.

N. M. BASU, G. K. RAY *and* N. K. DE, Calcutta.

Eight varieties of mangoes, viz. Langra, Fazli, Totapully, Bombai, Kishanbhog, Taraiha, Sepia and Benares Fazli, at their different states of ripening—green to fully ripe—were examined for their carotene, free vitamin C, total acid, *p*H and the sugar contents, by employing usual chemical methods. At least two specimens of the same variety of the mango and of the same state of ripening were analyzed. The data obtained revealed the following changes during ripening:—

(i) The carotene content of the mangoes increased enormously during ripening, by 50 to 680%, depending on the degree of ripening.
(ii) The free vitamin C content showed a fall by 10 to 180%.
(iii) The total acid content also decreased by 20 to 200%.
(iv) The *p*H values in all the cases were found to be slightly higher in the riper specimens than those in the comparatively greener ones.
(v) The sugar content showed only a slight increase (10 to 50%) due to ripening.

27. Excretion of vitamin C in milk.

S. N. Ray, Izatnagar.

It is now recognized that in animals like goats or cows, which are able to synthesize vitamin C within their body, the excretion of vitamin C is very constant and is quite independent of the amount given with the food. It is found, however, that when drugs like paraldehyde or barbitone are injected to these animals, the vitamin C concentration of milk is increased by 80–100%. On the other hand, the concentration is greatly decreased in animals suffering from cold.

28. Rôle of manganese in the biological synthesis of ascorbic acid.

M. N. Rudra *and* R. C. Lacy, Patna.

Fungi and bacteria have been found to synthesize more ascorbic acid (as estimated by titration with indophenol reagent) when grown in Brown's synthetic medium with starch, if the medium contains 0·0005 to 0·005% of added manganese as manganese chloride, than without it.

29. Rôle of manganese in the synthesis of ascorbic acid by guinea-pig intestines.

M. N. Rudra, Patna.

By injecting mannose solution containing $MnCl_2$ (Mn = 0·04%) into guinea-pigs it has been found that the ascorbic acid content of the small intestines increases as compared to the ascorbic acid content of the intestines of guinea-pigs receiving similarly either the sugar solution in distilled water or normal saline. This is good evidence for the governing rôle of manganese in the synthesis of ascorbic acid by animals generally.

Pharmacology

30. Deterioration in physiological activity of Digitalis.

B. Chatterji, Calcutta.

A five-years' study of this problem has just been completed and interesting data have been offered. For, despite common belief, evidences are slowly accumulating that Digitalis preparations, if carefully preserved, keep their potency for a fairly long time. A bio-assay record of 92 samples is submitted.

31. Biological assay of solutions of adrenaline hydrochloride.*

B. MUKERJI *and* N. K. DUTTA, Calcutta.

In the course of an all-India survey of the quality of drugs and medicinal chemicals, the Biochemical Standardization Laboratory has, during the last three years, analyzed more than 110 samples of Liq. Adrenaline Hydrochloride (1–1,000 solution) by using a 'pressor response' method in spinal cats. A number of these samples were also chemically assayed by Folin, Cannon and Dennis (1913) and persulphate colour reaction as modified by Barker, Eastland and Evers (1938).

It was found that quite a large proportion of the adrenaline solutions available in the market are *below par* in quality and strength. The factors involved in this process of determination have been investigated to a certain extent. Determination in strength as estimated by the physiological method is not always parallel to the findings obtained by the chemical methods of assay. Determination is often accompanied with a colour change but this is not always a sure indication of deterioration.

The importance of regular and systematic assay of adrenaline solutions, particularly those prepared from natural sources (suprarenal glands), are emphasized.

32. Bioassay of synthetic and natural thyroid preparations—a preliminary note.*

B. MUKERJI *and* N. K. DUTTA, Calcutta.

By using a modified bioassay method on tadpoles as originally advocated by Gaddum, a series of thyroid preparations prepared by Prof. B. B. Dey of the Madras Presidency College were assayed, using a standard thyroid gland powder, originally brought out from the British Drug Houses and whose iodine content was carefully analyzed, as the *standard* for comparison. In certain experiments, thyroxine-sodium tablets of B.W. & Co. were also used as the *standard*. The following samples were tested with the results shown against each. Only qualitative and approximately quantitative data are being presented at this stage.

		Approx. activity.
Natural	Dried thyroid gland ..	1(+)
	Desiccated thyroid (de-fatted)	1(+)
Synthetic	Iodo-casein (*a*)	4(+ + + +)
	Iodo-casein (*b*)	4(+ + + +)
	Homo-thyroxine ..	10(+ + + + + + + + + +)
	Thyroxine-sodium ..	11(+ + + + + + + + + + +)

33. Toxicity of a dialkylamino alkylamino acridine akin to 'Atebrin'.

U. P. BASU *and* A. N. BOSE, Baranagar (Calcutta).

In the course of investigations on acridine derivatives akin to 'Atebrin', 2-chloro-7-methoxy 5-(δ-diethylamino-butyl) amino acridine was prepared and found to be a yellow crystalline solid, m.p. 256–58°. Its toxicity was compared with the acridine derivative as present in 'Atebrin' and the results of investigations are being recorded in the body of this paper.

It is being noted that the dihydrochloride of the above butyl amino acridine derivative is more toxic to paramoecia than that of the corresponding salt of atebrin compound. This enhanced toxicity is also manifested from its lethal dose in mice. The $L.D_{50}$ of the above

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* Carried out in the Biochemical Standardization Laboratory (Govt. of India), All-India Institute of Hygiene and Public Health, Calcutta.

compound is about 0·190 mg. per gm.; whereas the corresponding L. D_{50} for the well-known antimalarial drug is found to be 0·212 mgm. per gm. The relative antimalarial activity is being studied.

Pathology

34. A study of the histology and physiological pathology of the human bone marrow from the post-mortem materials.

H. N. Chatterjee, Calcutta.

1. Post-mortem materials from some of the tropical diseases present great opportunities of studying the intimate vascular structure of the bone marrow as well as its functional pathology.
2. In diseases such as cholera and epidemic dropsy amongst other changes there is a great capillary dilatation of the marrow.
3. The collapsed capillaries are seen to consist of the two following varieties:—
   (*a*) Those which lie in between the adjacent fat spaces.
   (*b*) Those which lie in the somewhat quadrangular areas at the angles of the fat spaces.

The latter capillaries are comparatively more supported and the supporting tissue consist of recticular fibrils which stain well with silver. This variety of capillaries also seen to be in more direct contact with blood stream.

4. Changes associated with leocoblastic reaction are discussed and one of the important features of this is an increase of reticular tissue.
5. The venous sinuses can also be well studied in cholera together with their communications with the patent as well as the collapsed capillaries.

35. A study of the general capillary system and some other features of the post-mortem marrow from cholera patients.

H. N. Chatterjee, Calcutta.

1. There is an acute dilatation and engorgment of the normally collapsed system of the capillaries of the bone marrow in cholera.
2. The above capillary change is more marked than any other organ in cholera and might go some way in at least partially explaining the condition of great shock in this disease.
3. Owing to the widening of the above capillaries it is possible to study their openings into the venous sinuses of the marrow.
4. The venous sinuses are also distended and present an opportunity of study.
5. There is eosinophilia and variable amounts of leucoblastic reaction of the marrow.
6. Small lymphatic nodules have been observed in some cases.

Anatomy, including Embryology and Histology

36. The musculature of the posterior limbs of the Indian mongoos.

Brij Mohan Lal, Hyderabad-Deccan.

The Indian Mongoos is a typical terrestrial animal, with highly developed Mesogluteus, Biceps femoris, Quadruceps femoris and Gastrocnemius. The peculiarity about its musculature is the highly developed Ischio-femoris and the absence of Plantaris, which is expected to be well developed as in other Eutheria, especially those in which the Soleus muscle is not differentiated. The muscles on the whole are not well differentiated from one another as is noticed in the Quadruceps femoris, and the lateral and posterior muscle mass of the leg.

37. A macroscopic study of the brain of Semnopithecus compared with that of Macacus.

A. Ananthanarayana Ayer, Madras.

The brain of the Indian Langur, *Semnopithecus entellus* is described. A comparison of this brain with the brain of Macacus (rhesus and radiatus) is made. The following are some of the significant observations resulting from the study.

(1) The cerebrum of the Langur shows less moulding of its inferior surface by the cerebellum than Macacus. (2) The proportions of the weights of the forebrain, midbrain and hindbrain are 85 : 1 : 14 in Semnopithecus and according to Tilney 84 : 2 : 14 in Macacus. (3) While the Sylvian fissure meets the superior temporal sulcus in Macacus, the two sulci are separated by a gyrus in Semnopithecus. Further, a small extra sulcus has appeared in the Langur in the area between the intraparietal sulcus, the Sylvian fissure and the superior temporal sulcus; and another small sulcus between the superior temporal sulcus and lunate sulcus. All these indicate a progressive expansion of the inferior parietal lobule in the Langur. (4) The parieto-occipital complex in Semnopithecus anticipates to some extent what occurs in the anthropoid apes and man, and the arcus parieto-occipitalis is well seen. In the Macacus the parieto-occipital fissure is continuous with intraparietal and lunate sulci and the arcus is absent. (5) The precunous is larger in the Langur and consequently the parieto-occipital fissure is directed upwards and backwards, whereas in Macacus the fissure is directed upwards and forwards due to less growth of precuneus. (6) The corpus mammilaire shows two distinct elevations in Semnopithecus and is practically undivided in macaque. (7) The anterior commissure is comparatively smaller in Langur. (8) The pons is larger in Semnopithecus and the post-trigeminal part of the pons being better developed covers the corpus trapezoideum to a greater extent than in Macacus. (9) The olives are larger in Semnopithecus. (10) In Semnopithecus the cerbellum shows a better development of hemispheres and a smaller size of flocculus and paraflocculus.

It is thus seen that the Semnopithecus entellus has a definitely more advanced brain than that of Macacus. Its internal structure deserves a thorough study.

38. On the foetal vessels in the human placenta.

Y. Appajee, Mysore.

The paper gives the technique of preparing the corrosion specimens of the vascular and the duct systems of various organs and of entire foetus etc. In brief, it consists of injecting solutions of nitrocellulose in acetone or any of new resins in acetone into the blood vessels or ducts after washing them with acidulated water and pure acetone. The injected specimen is digested in concentrated hydrochloric acid and then after complete maceration, the hardened cellulose pattern is washed and preserved dry or in formalin. The writer has been preparing the casts of vessels of various organs and entire foetuses by this method for the museum. While studying the corrosion specimens of the placental vessels he found certain points of interest not mentioned in the textbooks. He has given details of the distribution of the blood vessels. The most important points of interest are:—

1. The two arteries are connected by a transverse anastomosis at the point of attachment of the cord to the placenta.
2. The two arteries are of almost same size though their areas of distribution are unequal.
3. Their terminal arteries are end arteries.
4. The veins of the placenta unite almost simultaneously to form the single vein at the point of attachment of the cord.
5. The arteries and veins end ultimately in a tuft of capillaries which give a characteristic appearance to the prepared specimens.

39. An unusual developmental defect in a new-born infant.

Y. APPAJEE, Mysore.

The report is made up of a dissection of an infant 8 days old. It showed hermophroditic condition of the external genitalia. Partial fusion and growth of genital folds and tubercle to give rise to penis and posteriorly persistence of urogenital sinus bounded by what appeared as labia. On dissection, the hindgut opened anteriorly into the 'penis' and the ureters and mullerian ducts opened into the pudendal cleft posteriorly. The gonads showed ovarian tissue. This anomaly is discussed in the light of embryology of the cloaca and its fate.

40. The extent of Brunner's glands in man and other animals.

(MISS) E. A. MICHAEL, Madras.

An attempt has been made to determine histologically the extent of Brunner's glands in the intestine of man and other animals. The glands were found to extend 0·75 cm. to 1 cm. from the pylorus in rat; 24 to 28 cm. in guinea-pig; 30 to 38 cm. in rabbit; 21 to 26 cm. in sheep; 17 to 49 cm. in cow; 1·25 to 2 cm. in dog; 2 to 2·5 cm. in cat; 3·75 cms. in monkey and 13 cm. in man.

It is observed in general from these figures, that the extent of the glands was greatest in herbivorous, less in omnivorous and least in carnivorous animals. Villemin and others in their observations found a relationship between the situation of the opening of the pancreatic duct and the extent of these glands. Such relationship is not borne out by my observations.

SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE

President:—GOPESWAR PAL, D.Sc.

General Psychology

1. The mind in heights, depths and in the arctic cold.

N. N. SEN-GUPTA, Lucknow.

The environment impresses upon the personality a new order of mental life. In some cases the basis of such change lies in a new order of sense impressions. In other cases it lies in the emotions, ideas and new outlooks. In certain other instances, again, the change in the mental personality arises from the new vocations that man has to take up in a particular geographical setting. The paper attempts to consider some of the factors of the geographical environment that alter the character of the mental personality.

2. Assessment of the beauty-value for aesthetic stimuli.

N. S. N. SASTRY, Mysore.

The experience of beauty is the result of the dynamic co-mingling of the subject and the stimuli. The final beauty-value is an emergence, dependent upon the stimuli and its aesthetic worth. Ten coloured reproductions of paintings and seven musical selections were presented to 44 subjects. The subjects were asked to indicate the 'affective judgment' of each stimulus by declaring if it was pleasant or unpleasant. They were also asked to give 'affective score' for each stimulus on a 10-point scale. In the case of pictures, they were asked to rank them for their beauty-value.

The frequency of the affective judgment was worked for each stimulus. The average affective score per stimulus, also, was worked out. The coefficient of correlation between the frequency rank of affective judgment and affective score is $+0{\cdot}860$, P.E. $\pm 0{\cdot}0419$, and $+0{\cdot}932$, P.E. $\pm 0{\cdot}0417$ for pictures and music respectively. The average affective rank per picture was also worked out. The coefficient of correlation between the affective judgment and group rank is $+0{\cdot}961$ and $+0{\cdot}937$ respectively.

The three criteria yield their total rank. Ranking this total gives us a measure of the beauty-value of each stimulus which holds good for the group.

3. Outlines of the Hindu psychology. Rasa and emotion.

MANMATHANATH BANERJI, Calcutta.

There is a very rich volume of work on affects and emotions, which remain embodied in the works of (A) the Samkhya, (B) the Natya and the Alamkara Sastras, and (C) the Kama Sastras. From prehistoric times (long before the rise of the depth school of Psychology—the psycho-analysis—and long before the recent discovery of the implications of emotional traits in the performance of intelligence tests) supreme importance of affects, feelings, emotions, moods, temperaments and personality traits on the actual behaviour and performance of men was recognized by writers on Hindu Psychology.

For every cognition there is in the affective state or *Bhava* a change which always initiates a series of affective adjustments depending on the moment and the mental make-up of the experiencer. And if the same change is of certain intensity it also expresses itself by involuntary bodily reverberations. Some of them may again be very well known as typical indices of particular affective states or Bhavas. According to the Bharatian terminology the cognition is called a *Bibhava,* the train of affective states *Sanchari* or *Vyabhichari Bhava.* Behavioral expressions are known as *Anubhava* and some specially typical of them are designated as *Satvikabhavas.* These four influencing one another and blending together accentuate any of the eight principal innate permanent tendencies or *Sthayibhavas,* viz. love, laugh, anger, sorrow, energy, wonder, aversion and fear (which generally lie dormant) into an appropriate form of emotion or sentiment. An emotion when initiated by the artificial situation of reading or hearing pieces of poetic or fictional composition or the witnessing of a drama or any other performance is invariably one of relish or pleasure and is called a *Rasa* or poetic sentiment.

4. The evolution of cognitive abilities according to the hormic theory.

P. S. NAIDU, Annamalainagar.

The evolution of primitive emotions into cultured sentiments is very fully described by McDougall. In fact, the theory of sentiments, including character formation through sentiments, is McDougall's most original contribution to contemporary psychological theory. The charge has, however, been levelled against hormic psychology that it neglects the development of the cognitive aspect of mental structure. This paper meets the charge and shatters it to pieces by showing how meticulously careful McDougall is in tracing the cognitive development of the human mind through all its intricate stages. Each sentiment has its cognitive side, and with the evolution of sentiments, their cognitive aspects also evolve. Cognition is shown to be rooted in conation. That, of course, is the great merit of hormic psychology.

5. Mental factors in attention errors.

J. K. SARKAR, Mazaffurpur.

The main purpose of this paper is to present the classification of poor observers. Tachistoscopic experiment made on 350 subjects are, to a great extent, helpful in distinguishing the different types of attention errors and correspondingly different classes of poor observers. Introspective and experimental observations carried on in diverse ways show that some of the attention errors especially in the form of meaningful words used as responses to nonsense letters are not direct but influenced reactions. In such cases attention is either reproductive or anticipatory.

The subjective factors or tendencies that are responsible for meaningful and other wrong responses are clearly brought out in this paper.

6. Organic and kinaesthetic factors in the estimation of time.

S. K. BOSE, Calcutta.

The importance of general bodily conditions in the estimation of time has been emphasized by many. A good deal of work has been done in this field but many aspects of the problem have not been touched upon by the laboratory workers. The present paper reports the results of an investigation of our ability to estimate long periods under conditions which exclude external criteria as far as practicable. The method followed is that of introspective analysis of the conscious internal cues in terms of which temporal estimation is made. Attempt has also been made to study the influence of the varying degrees of kinaesthetic strain on the time sense.

7. Experimentation in Psychology of Religion.

RAJNARAIN, Lucknow.

The paper presents the experimental work of Girgensohn and Behanan with a view to showing the feasibility and desirability of more experimentation in Psychology of Religion.

8. A plea for psychologists' interest in psychical research.

B. L. ATREYA, Benares.

Present-day Psychology does not take much interest in the study of 'supernormal psychical phenomena' which are being exclusively studied by what is known as 'Psychical Research'. This state of affairs is harmful. The concepts and principles of contemporary Psychology are incapable of comprehending and explaining many actually occurring phenomena of life. In this paper the origin, growth and achievements of Psychical research and its importance for Psychology have been discussed. Extra-sensory perception (including Clairvoyance, Clairaudience and Premonition), its bearing on Psychology, Telepathy, etc., have been critically examined. Experimental basis of telepathy, the brain-waves theory of telepathy as advanced by Sir William Crookes have been stated and criticized. Attempts have been made to explain Trance-personalities and Possession of various types which are not entirely explicable in terms of general and abnormal psychology, nor in terms of the 'Compound theory' of Broad. Pros and cons of Telepathy versus survival have been thoroughly discussed. Incalculable importance of these studies for Psychology, need and field of such research in India have been emphasized.

9. The social sanction in humour.

RABI GHOSH, Calcutta.

Humour affords an economy of psychic expenditure. A humorous incident or story can only be enjoyed in a group of people when they are similarly attuned for humour, i.e., when certain anxiety is pressing for the 'scotomization' of reality and the severity of the Super-Ego is waved temporarily at least. The various Egos of the people constituting that group by common effort induce the sanction for indulgence in the primitive behaviour of being aggressive.

10. Effect of change of orientation. Maze learning.

B. KUPPUSWAMY, Mysore.

If a maze is learnt by rats when it is in one position what will be the effect of changing the maze to a different position upon the performance of the rats? This problem was studied by changing the position of the maze after the rats had thoroughly learnt to thread it.

The change in position does not appear to affect the number of trials per rat per day. But on the one hand the number of correct dives decreases and on the other the number of errors increases to a considerable extent. Though the problem remains the same, because the direction of movement is changed we observe that the old pattern of movement interferes and brings about a lowering in the level of performance.

11. Experiments on colour preference.

S. Banerji *and* S. C. Mitra, Calcutta.

Study of colour preference, an important part of the problem of aesthetic perception—Previous experiments in the field—Very few experimental studies with special reference to Indian Subjects—Sastry's work—Some preliminary studies by Mitra—Object of the present investigation—Study confined to Indian subjects only—Large number of cases investigated—Detailed report of 100 cases only presented in this paper—Methods of the experiment, materials, etc., described—Subjects divided into different age groups—Preference for every age group analyzed and graphically represented—Results compared with those of the previous investigators—Conclusions.

12. The psychology of response to literature.

C. N. Menon, Benares.

The operation of the principle of imaginative identification in literature is hinted at in works of Sanskrit poetics. Some modern psychologists hold that the spectator projects his own ideas and emotions on the work of art; some others believe that the spectator enters into the object contemplated. Both are wrong: the character with whom the spectator establishes identification is not an external entity. When a man witnesses *Hamlet*, the inner configuration which is known as his empirical personality is, as it were, replaced by another which can be called the potential Hamlet in himself.

Thinkers like Tagore who posit an aesthetic *per se* and empty art of intellectual, emotional or sensuous content are no less wrong than Ellis and others who find in art the purposive play of instincts.

Since literature brings the unconscious potential to the surface, it resembles psycho-analysis. Jones says that the spectator identifies himself with Hamlet who has identified himself with Claudius. What the spectator witnesses is a conflict within himself between two aspects of an identification. Literature appears to be the attempt of mental life to re-establish unity. It is the spontaneous curative activity of the mind. The proper response to great literature resolves conflicts and leads to the integration of personality.

13. Psychology to-day.

Rajnarain, Lucknow.

Under this ambitious title are presented the modest results of an enquiry into the frequency of words referring to different branches of psychology from an authenticated dictionary of Psychology.

14. Factors in the discrimination of intensities.

N. C. Gangopadhyay, Calcutta.

An attempt has been made in this paper to determine the factors which are responsible for discrimination of intensities in the field of kinaesthetic sensations. The findings are based chiefly upon introspective analysis.

Introspective evidence shows that discrimination is possible in both the conditions of subjective and objective attitudes. In the first stage, awareness of some sort of imaginal representation of the standard was present with a definite psychological set. During the later stage the awareness of change of this psychological set was the basis of discrimination. In those cases where the psychological set was somehow disturbed there arose much confusion. Endeavour to bring back the set was attended with much vocalization regarding the perceptual components of the comparison stimulus and the imagery of the standard. Under certain states it has been found, however, that the sensation loses all its attributes and there remains a unique experience in which no discrimination is possible.

15. Sleep.

UDAI BHANU, Indore.

Sleep is a passive reflex. Relaxation is the unconditioned stimulus that evokes it. Any neutral agent may be made to produce sleep by way of conditioning.

Thirty-seven sleepy persons have been studied. Their observations have been recorded and many interesting conclusions have been drawn. Lastly, biological value of sleep has been critically examined.

16. Analysis of the process of comparing.

S. K. BOSE *and* G. PAL, Calcutta.

Lifted weights and pendulum-sounds were employed as materials. Introspective account of the process of comparing for easy, difficult and doubtful cases was obtained and analyzed. With different stages of practice, different types of processes were recognized.

17. Time perception and thing perception.

PARS RAM, Lahore.

Pátanjali enumerates the mental consequences and achievements following a sustained concentration on a unit of experience. These consequences are interpreted in terms of modern psychological concepts.

18. An experiment on colour preference.

D. NAYEK, Calcutta.

Colours are exposed to the subjects in pairs. Introspective reports regarding their preferences have been obtained from a large number of subjects. It is found that deep colours are mostly preferred and association of ideas play an important part in determining colour preference. A common factor influencing preference is close association of the preferred colour with subject's love objects.

19. An exposure apparatus.

G. BOSE, Calcutta.

This paper gives a description of an exposure apparatus, devised by the writer and prepared locally, is suitable for demonstration work. A series of different forms of materials, e.g. pictures, nonsense syllables, etc., can be automatically exposed for any length of time. The time of each exposure as also the interval between two exposures can be varied at will. The apparatus works on a new electrical escapement principle and runs without attention once the switch is turned on.

20. A new type of campimeter.

M. GANGULY, Calcutta.

The paper reports a new type of campimeter devised by the writer. There are arrangements whereby investigations along different meridians are facilitated by comparatively easy manipulations.

Child Psychology

21. A lead from healthy childhood to wholesome adolescence.

(Mrs.) K. V. Thakore, Baroda.

Periods of Childhood and Adolescence have engaged attention of almost all leading Philosophers, Poets, Reformists, Educationists, Psychologists like Rousseau, Nietzsche, Shelly, Durant, Shaw, Tagore, Robinson, and others. Significance of these periods discussed from the individual as well as national point of view. An attempt is made in this paper to show that these two periods form two main periods during which structure of human life is built and during which it evolves.

Stress is laid on the adaptability of the child. 'Man is not born Human.' Action and reaction of innate capacities and environments are examined. Importance of guidance and care in both these stages by parents, family, teachers, etc. Helplessness of the child after birth; potential equipment for emotional and intellectual growth.

Factors depending upon economic, social, national and educative conditions surrounding the child and accidental crisis like war, famine, etc., which come in the way of the healthy development of the child are examined.

Generally, adolescence is colourful and vivid period during which nature builds up a man or a woman, as it were, with toying and tricks.

Nothing is shocking to a child. One should never get shocked at the behaviour of a child (Records to illustrate this). Never forget the first child when you get another; give children security and feeling of welcome in the world; give them love (rationally) and above everything to express themselves.

The child in India; its environments; lack of responsibility on the part of the parents; the degradation of the teaching profession. The Herculean task of the educationist. Education a noble profession, though poorly appreciated by the public and the authorities alike. A few practical suggestions.

22. Child guidance experience in Bombay City.

K. R. Masani, Bombay.

The Child Guidance Movement is one of the most outstanding contributions of the twentieth century in the field of child welfare. The Child Guidance Clinic is a clinic for the scientific study and treatment of children showing behaviour and personality disorders, as also those exhibiting educational backwardness or physical symptoms due to psychological causes.

In Bombay a Child Guidance Clinic was opened a little more than three years ago in order to provide the community with a clinic where children with behaviour problems could be treated along modern scientific lines, as also to provide field-word training in psychiatric social case work for the students of the Sir D. J. Tata School of Social Work. The Clinic tackles the behaviour problems of children with the four-fold approach of Pediatrist, Psychiatrist Social Worker and Educational Psychologist. These workers co-operate with each other and a treatment programme for each child is jointly formulated at Case Conferences. The methods employed by these workers are described.

The results for the years 1939, and 1940 show that 74% and 70% respectively of children who attended regularly for treatment showed definite improvement, under the categories of cured or very much improved, and improved. A few successful cases are cited as illustrations of the type of children dealt with, the methods employed and the results obtained at the Clinic.

23. An experiment on time sense in children.

K. D. Ghose, Dacca.

Sense of time proverbially weak in children—Children's idea of chronology in the History class—Investigations carried out in the West—Work of Sturt, Oaken and Kaye—their findings—the test material by which the children were tested in the present case—results of the experiment—not correct to say time sense does not develop before adolescence or even the age of 16—the visual conception of time in children and adults—discussion of the means by which time sense is strengthened in children.

24. Introspection and the reasoning of children.

T. K. N. Menon, Baroda.

I. *Introduction:*

Piaget, the great child psychologist advances his theory of Ego-centrism to explain children's reasoning. The present writer during 1933–35 investigated in the Madras University the correctness of this theory. This paper deals with one aspect of the investigation, viz. 'Can Children between 7 and 10 introspect? If they cannot as Piaget argues, is the failure due to Ego-centrism?'

II. *First Study:*

Burt's Reasoning Tests were revised to suit local requirements; these were administered to 50 children (ages 8-9) of the Kindergarten Section of the Saidapet Teachers' College and the subjects asked as to how they reasoned. The results showed that a large number could introspect correctly and failures were due to one or more of the following reasons:—

(*a*) Children's inability to express all their thoughts due to language difficulty.

(*b*) Their inability to understand the adult requirements.

(*c*) Their assuming that what is expressed is complete.

III. *Second and Third Studies:*

40 Children (ages 8-9) were similarly tested with four simple arithmetical problems which did not entail language difficulty in answering. The percentage of successes at introspection was over 90. The same tests when given to 20 children of the next lower age (7-8), the percentage of successes was equally high. The answers did not reveal the three stages of evolution of children's introspection outlined by Piaget.

IV. *General Conclusions:*

(*a*) Indian children between 7 and 9 can introspect correctly when (1) the steps of introspection are not complex and (2) the expression of the steps does not entail verbal difficulty.

(*b*) The reasons arrived at in Study I appear to be the correct reasons for the child's failure at introspection.

(*c*) The relation that Piaget draws between children's incapacity at introspection and Ego-centrism appears to be far-fetched and fantastic.

25. The extent of 'General Information' as varying with different age levels.

S. Sinha, Calcutta.

The test for 'general information' forms but an item of the battery of standard intelligence tests. In the present investigation a test for general information, based upon the Terman model but translated and adapted to suit conditions of Bengal, has been administered to two thousand school children, about seventy-five per cent boys and twenty-five per cent girls. The analysis of the result shows that the extent of general information steadily rises from the age group of eleven years to the age group of seventeen years, and that it shows fair correlation with the total score values.

26. A study into the basis of primary reading literature.

JAGDISH SINGH, Punjab.

In order to discover the most suitable material for primary reading lessons an attempt was made to study the children's interests, their cultural environment and their cultural background. The ages of the children ranged from 6 years to 10 years. They belonged to both the sexes and were drawn from different urban areas of the Punjab coming mostly from the well-to-do middle class families.

(*a*) Stories relating to the cultural heritage of the Panjabi children, (*b*) spontaneous literary attempts, (*c*) and school songs of children were our materials of study. Common stories, selected articles from their manuscript magazines, the popular school songs all these formed the basis of primary reading literature.

This printed literature was tested and tried with the primary children. The conclusions that became obvious from this study were—the child's own environment furnishes us with the best material for children's literature (both primary reading lessons and supplementary literature); this is possible only if the child's spoken language is the medium of instruction in the primary classes.

27. The standpoint of child guidance.

R. M. LOOMBA, Delhi.

There is a tendency prevalent in child guidance circles to lay aside the psychology of child development and to concentrate on what is usually called the 'practical' problem of making the child social, intellectual, moral, religious, conscientious and the like.

The paper points out wrong assumptions, grave misconceptions and dangerous implications in such a so-called 'practical' standpoint, and brings out the necessity of adopting a psychological standpoint in child guidance, which would have for its object the facilitation of the spontaneous development of the child through natural psychological stages of growth. At these stages, since he is really still a child, none of the categories of the virtues of adult manhood like morality and immorality are applicable to him.

Thus conceived, child guidance would principally concentrate on facilitating the growth of the normal child. The handling of the difficult or abnormal child, though not less important, would yet be only one of its special problems.

28. A new Arithmetical apparatus for children.

RABI GHOSH, Calcutta.

The usual method of teaching children the numbers and arithmetic calculations is very uninteresting, unreal and abstract. An attempt has been made to devise an apparatus which will remove the tedium of learning and make the teaching of arithmetic realistic and useful. Through the joy of learning child's education will afford scope for the expression and satisfaction of curiosity. The apparatus is simple for the teacher to acquire the knowledge of its operation and cheap enough for the guardians and the schools to purchase.

Educational Psychology

29. Children's attitude towards School-subjects.

(MISS) SANTA CHOUDHURY, Calcutta.

The present paper reports the results of an investigation carried out on school children of Bengal for the last three years. So far 2,500 children of both sexes belonging to different parts of Bengal have been tested from the psychological standpoint. The object is to find out the natural interest of school-children with regard to different school-subjects The tests called 'Preference Tests' were given to all classes of high schools, i.e., beginning from Class II to Matriculation class. The age of children varied from 6 to 18 onward. In order to arrive at a greater reliability the same subject was tested on three subsequent days by three different 'Performance Tests' devised by the author.

Statistical calculations of these data show certain problems regarding school subjects and children's attitude towards them. The solution of which the author hopes will throw light on certain present-day educational problems.

30. The theory of two factors and a test of the theory.

S. M. MAHSIN, Patna.

The theory of Two Factors is based upon the discovery of a 'hierarchical' arrangement shown by the correlation coefficients obtained from the measurement of mental tests. But the 'hierarchy' is not always very apparent. The inter-columnar correlation was for some time used as an index of the hierarchy but was afterwards replaced by the Tetrad Difference criterion. The tetrad difference, i.e. the difference between the cross products of two pairs of correlations in a correlation table, approximates toward zero. But the actually obtained tetrad difference shows a slight departure from zero. This discrepancy between the theoretical and the obtained values is due to the error of sampling or P.E. To prove the hierarchy the tetrad difference equation should be satisfied within the limits of the probable error of sampling.

The 'hierarchy' can be explained only on the theory of Two Factors, the general factor or 'G', which by its common presence in all cognitive abilities determines their correlations, and the specific S's. The magnitude of 'G' differs in different abilities, hence the hierarchy. An overlapping group factor, i.e. common to some of the correlated abilities, disturbs the hierarchy.

A test of the theory is appended. A frequency distribution of 210 tetrad differences, obtained by the writer, is given. The suggested criteria are applied and a striking agreement is shown between the obtained distribution and the theoretical one expected from the divisibility into 'G' and 'S'.

31. Traditional examination *vs.* New type examination.

HEM CHANDRA BANERJI, Dacca.

Out of the criticisms of the traditional examinations on the ground that the marking is subjective and consequently neither valid nor reliable there arose the new type examination which may be used to test a subject of the school curriculum. An experiment with the essay and the new type tests in English and Geography was carried out in two different classes of two High English schools at Dacca. There is general agreement that the new type test has advantages which the traditional examination does not possess. It has been found that much that is being measured with essay type of tests can also be measured with objective examination items, but the mechanical, rote procedures tend to predominate more in English. The high correlation between the teachers' judgment and the traditional examination marks and the low correlation between the teachers' judgment and the new type examination marks indicate that the judgment of the class teacher is affected considerably by his bias, prejudice or personal opinion. Attempts have been made for the solution of the problem of combining the best in the traditional education with the best that can be found in the way of more accurate, reliable and objective substitutes for the traditional examination.

32. Silent reading *versus* Articulate reading.

(MISS) SHANTI AGARWAL, Lucknow.

It is usual for certain people to articulate sounds as they read. It is equally common for others to read without any effort at articulation. The habit of reading aloud is inculcated with an eye to the psycho-physical advantage that ensues from the induction of the visual, auditory-kinaesthetic (verbal) and auditory impression at the same time. At a certain age, however, there is the risk that due to the above three factors both comprehension and memory would diminish in value. The occurrence of these three processes may increase the amount of time needed for mere visual reading and thus the longer time-value would be added to the other handicaps.

The problem is to find out at what age and to what extent silent reading is advantageous. The analysis of this would also enable us to know how and at what age the articulate reading becomes less advantageous.

There are many aspects of the problem of reading which have been studied by different psychologists from time to time by inventing tests for them.

I have used Pintner's method to measure the amount of comprehension both in silent reading and articulate reading. The average amount of comprehension and also the correlation between the two types of reading have been calculated.

The result of the above tests shows that as the age increases, the amount of correct answers increases, and that of errors decreases. But the amount of absurdities does not follow this course. There is a gross amount of correspondence in the two types of reading in early days. The correlation tables show that there is no significant correlation between the two types of reading.

33. An investigation into the merits of two types of examinations.

N. MUKERJI, Calcutta.

The present investigation was conducted in the Teachers' Training Department, Calcutta University. 450 students from Matriculation classes were examined in English. Two sets of questions were prepared. Form A comprised of questions as they are set in usual final examinations, whereas Form B contained questions requiring *definite* answers. Questions in both the forms were of equal difficulty. Along with these two series of questions Comprehension and meaningful Memory tests were used. The system of scoring was purely objective. Marks were converted into *z-scores*. Distributions were determined. Partial correlations indicated strong influence of memory on customary type of examination (Form A). Whereas the weight of comprehension was greater in the new type of examination (Form B).

34. An attempt at discovering the degree of cramming.

S. Jalota, Sholapur.

The results of about 3,300 candidates in Logic at the Bombay University, Intermediate Examination in 1941, have been statistically treated to discover the degree of cramming present among the answers. It is believed that a crammed answer, if relevant, will secure higher marks; and if that is irrelevant, then it will get much lower marks. So that a sufficient discrepancy between the marks of the various answers of a given candidate, will give a clue to his cramming to some extent. The method employed is similar to that used for finding the coefficient of Colligation.

35. Steadiness in performance in certain school subjects and their inter-correlation.

S. S. Majumdar, Lucknow.

The paper analyses the marks of a large number of students at their examinations. It tries to elucidate the *notion* of *true* mark on the basis of examination mark. A statistical treatment of the data seems to yield certain interesting conclusions in regard to the level of performance and the ability of the group of pupils whose marks are taken as the basis of the present paper.

36. Some observed discrepancies in mental testing.

Rabi Ghosh, Calcutta.

An attempt has been made by Mr. S. Sinha through the guidance of Prof. G. Bose in the Department of Psychology, Calcutta University, to standardize a Group Test of Intelligence. Amongst other difficulties, the difficulty of ascertaining the correct ages of the Testees in all cases produced some discrepancies which interfere with the standardization of intelligence of those put to this test. A tentative suggestion is made to tackle these discrepancies.

37. A note on the learning of a 'backward' rat.

B. Kuppuswamy, Mysore.

One backward rat was found to dive in a water maze after the water was let down. Attempts were made to isolate the 'conditioning' factor by varying the different conditions. It was found ultimately that it was conditioned to a decrease in the level of water.

The educational implications of such analysis and isolation are briefly pointed out.

38. Studies on the types of intelligence.

Sachindra Prosad Ghosh, Calcutta.

The two types of intelligence, concrete and abstract, are measured by performance and verbal tests respectively. The present study is an attempt to show how far the two types are related and in what respects they differ from analysis of statistical and introspective data. Scores of 213 subjects in the Passalong and the Dearborn Formboard tests as well as their scores in the Terman Merrill 'L' and 'M' Forms tests have been taken into calculation. While the correlation between the scores of the 'L' and the 'M' Forms is as high as $\pm 0{\cdot}762$, that between the Passalong and the Formboard tests is only $\pm 0{\cdot}413$. The correlation between the performance tests and the verbal tests is still lower. The correlation is, however, positive in every case. These results tend to prove the presence of some common factors in all the tests and also that of some specific factors peculiar to each test. For understanding the nature of these factors detailed introspection of the mental processes involved in dealing with the different tests has been taken from several trained subjects which reveals interesting characteristic differences of the two types of intelligence as well as of the two forms of performance tests.

39. Influence of language of question paper on the scores in Geometry.

N. MUKERJI, Calcutta.

This paper forms the second part of the series of experiments which are being conducted by the Calcutta University (Teachers' Training Department) to determine the influence of language on question papers in Matriculation Examination. The results of the first part have been published in Indian Education, Vol. I, No. 1. An attempt has been made in this paper to determine the amount of difference in scores obtained in Geometry when the questions are set in Bengali and in English. Procedure of application of the test questions and marking them was the same as in the first part of the experiment with the difference that the questions set this time were of objective type and that raw scores, before statistical treatment, were properly weighted. From results obtained it may be said that students score higher marks on question papers set in Bengali than on those set in English by 17% approximately.

40. A study of the alternative methods of multiplication.

A. MOKTADER, Dacca.

The aim of this investigation was to determine the relative advantages of the two methods of multiplication, the Old and the New. The Old method begins with the unit figure of the multiplier and the New method with the other end. Dr. Ballard, in order to decide, which of the two procedures work better in practice carried out an experiment in a number of elementary schools and found that the average error per sum under the Traditional method was 1·32 and that under the New method 1·27 Dr. Ballard measured only accuracy. In this investigation, however, both accuracy and speed were measured, and the New method proved distinctly superior to the Old method in both respects. The findings of this investigation are based on the examination of 423 cases who appeared in both methods. Relative advantages in respect of accuracy and of speed are discussed in this paper.

Vocational Psychology

41. On current theories of propaganda.

(MISS) T. HABIBULLAH, Lucknow.

The growing importance of Propaganda to Psychologists and Sociologists—More interests taken by Psychologists.

Two types of theories: (1) *psycho-analytic*, and (2) *behaviourist*—Psychoanalytic theories represented by Amber Blanco White's 'The new Propaganda' and Osborn's 'The psychology of reaction'—Examination of these two views.

Behaviouristic theory as given by Chakotin in 'Rape of the masses' based on conditioned reflexes. Biddle's theory as described in 'Psychological theory of Propaganda' depending on 'emotional conditioning'—Other current theories—One-sidedness of all these views.

Need of a more comprehensive theory—Suggestions of mine—Complex nature of propaganda—Stimuli—Various levels of mind, e.g., Time level, Ego level, etc., to which propaganda appeals. Conditions under which propaganda succeeds.

42. Concrete Intelligence as measured by the Dearborn Formboard test and the Passalong test.

RANJIT KUMAR DE, Calcutta.

The Dearborn Formboard test and the Passalong test have been administered on 100 testees of three different age levels and the scores in the two cases have been compared. The individual peculiarities in response have been studied from observation of the behaviour of the subjects during operation of the task as also from their introspective reports. The points of difference between the two tests have been discussed in the light of the experimental data.

43. Study of character traits from Performance tests.

D. GANGULY, Calcutta.

Study of character traits from handwriting, facial expressions and other behaviours has been made by several workers. Performance tests such as the 'Passalong', the 'Cube construction', the 'Formboard' tests, etc., require varieties of operational movements which yield unique opportunity for studying behaviour and thence to deduce character traits. The present writer has observed behaviour-peculiarities of a large number of subjects examined in different performance tests. The results show that the presence of certain specific character traits goes with certain types of performance tests.

44. Employee selection and occupational analysis.

SAROJENDRANATH ROY, Calcutta.

That everybody is not fit for all jobs is a recognised fact. A misfit is responsible for heavy financial losses not only to the company to which he belongs but to the family also of which he is a member. The losses may be avoided if proper precautions are taken in time. For the selection of right person for the right job the ideal method is the psychological analysis of the person concerned, on the one hand, in order to have an idea of the qualities that he possesses, and, on the other hand, detailed analysis of the occupations themselves to find out the demands that would be made on the persons entering them. It is only then that a proper adjustment can be made between the 'possessions' of the persons and the 'demands' of the occupations. Various ways in which selection has hitherto been made and is still being made in our country—their defects pointed out. The psychological method of selection can be adopted here in spite of some difficuties—methodical and systematic procedure necessary. One indispensable requisite is the careful analysis of the vocations. The writer for some time past has been collecting information about the different types of occupation existing in the country with special reference to qualifications required. A practical scheme for the analysis of vocations is suggested.

45. Comparative study of Kelly's Construction-Ability test with Cube Construction test.

GAURANGABHUSHAN GHOSH, Calcutta.

Cube construction test which is one of the commonly used performance tests bears a high correlation with Kelly's test. The former test measures what is called 'concrete intelligence' and the latter indicates ability to initiate as also to execute a task. Results tend to show that both the tests probably measure the same trait.

46. Stenquist test at Calcutta.

P. Roy, Calcutta.

There is reason to believe that the mechanical ability of Indian boys may not be at par with that of American boys, who have greater opportunities to be mechanically minded, being brought up in a place of high degree of Industrialization. An attempt is being made in this paper to see how far Edna Willis Mcelwee's findings regarding Stenquist test in America hold for Indian conditions. Stenquist test is now being conducted by the Applied Section of the Psychology Department of the University of Calcutta and a large number of school boys has been tested.

Edna Willis Mcelwee's findings referred to above are the following:

1. There is a definite relation between the mechanical performance and the chronological age.

2. Dull boys make a high mechanical score than bright boys of the same chronological age.

3. Older boys of inferior intelligence make a higher mechanical score than younger boys of the same mental age. Those findings have been compared with those of ours.

47. Investigation of a few cases of criminals.

B. Ghosh, Calcutta.

The present writer is engaged in the study of criminals with a view to render them psychological aids. From his interview with convicted prisoners between ages 18 and 24 who have been found guilty of forgery and stealing the writer is forced to the conclusion that these criminals are either mentally deficient or psychoneurotic or both. No psychotic case has been found so far. Enquiry into the cause that led to the crime shows in most cases that the low moral was contracted during the early school days due to the influence of undesirable associates and non-congenial home. Sex factor is also found predominant in many cases as inducive of crime in later ages. At the present moment the writer is psycho-analyzing a few criminals for detection of the unconscious motivation. From answers to the questionnaires by the criminals themselves and from his observations the writer is inclined to think that crime may be prevented to a large extent if the school authorities with the help of child guidance experts segregate the feebleminded and also those with criminal propensity from the normal children and arrange for special training of the former, if possible. In many cases those already convicted may be reclaimed by giving them suitable vocational training in the prison and finding occupations for them when released. The writer appeals to all those interested in the welfare of the society in general and in the welfare of the criminals in particular to help the growth of an organization that will provide healthy school life and in case of convicted offenders help them to earn an honest living.

Abnormal Psychology

48. Remedial work with speech defectives in the child guidance clinic of the Sir Dorabji Tata Graduate School of Social Work, Bombay.

(Miss) Katayun H. Cama, Bombay.

Speech defects are attributed to various causes by different scientists. Stuttering, for example, is interpreted as fixation of infantile oral eroticism, as an emotional difficulty, as a physical symptom of psychic difficulty, as disruption of speech due to fear or insecurity, as a pathological social response, as an inhibition which occurs before the speech reflex is securely established, as conflict between the two brain hemispheres or as due to etiological and differential factors. Other types of speech defects also occur due to many of the above factors.

Remedial work starts with correction of organic defects and improvement of the general health of the patient. Then family and social environments are looked into; mental complexes are resolved; self-confidence is built up and speech exercises are given building up gradually the speech reflexes. No treatment programme is valid unless the diagnosis by the speech therapist is verified by the physician, surgeon, neurologist, psychiatrist and endocrinologist according to the exigencies of the case.

Some cases treated at our Clinic are those involving stuttering due to bad health, loss of speech due to inward rebellion and ego-frustration, stammering because of sibling jealousy and muteness since birth due to extended epiglottis.

49. Studies in word association.

(Miss) P. Das, Calcutta.

Tests conducted mainly on girls—some boys and some mentally defectives too were tested.

Procedure, Theory, Materials, Condition of Experimentations were described. Method of Interpretation of obtained data was critically examined.

Findings relating to (*a*) Frequencies of Noun, Adjective, Verb; (*b*) Relation of Stimulus—Response; (*c*) Reaction time; (*d*) '*c*' indicators were discussed.

Conclusions regarding differences in the nature of the Responses of boys and girls were tentatively drawn. Comparative study of Responses of our children and those with Kent-Rosanoff was made. Some illustrations and their interpretation were given in the paper.

50. Regression.

P. S. Naidu, Annamalainagar.

Regression is a very useful operational concept with immense diagnostic value for therapeutic purposes. Freud has demonstrated its utility beyond any shadow of doubt. But, the question is whether the Freudian psycho-analytic type of regression is the only one of its kind. William McDougall is constrained to believe that there are other types as well. Three types of regression may be distinguished—(1) regression to primitive types of pictorial thinking in dreams and in certain kinds of neuroses, (2) regression in the sex complex to the polymorphous perverse infantile form, and (3) regression of sentiments to primitive emotions, sex, of course, being one of these primitive emotions. McDougall thinks that regression is always towards some one or other of the primitive instinctive impulses, not to sex alone. Freud, according to McDougall is wrong in having taken a monistic view of the primitive level of mental structure. This paper thrashes out the whole question, and shows that there need be no antagonism between the Hormic and the Psycho-analytic positions, and that the latter is the logical culmination of the former. Incidentally an important contribution is made towards an evolutionary conception of the Hormic theory of instincts.

51. Some observation of mental symptoms in a case of typhoid.

RABI GHOSH, Calcutta.

The case is of a boy of five years old. Alongside his physical symptoms of temperature, etc., certain other symptoms were noticeable which could be understood psychologically.

52. Parental psychology.

J. K. SARKAR, Mazaffurpur.

This paper is based on observation of different types of parents, such as, over-anxious, over-loving and flattering or bribing, foppish, quarrelsome, and ideal ones.

Concrete cases of such parents are cited. Psycho-analytical study gives a true insight into their inner nature. It points to the fact that the parents' desire for ownership or monopoly is in diverse ways injurious to the child's individuality and autonomy. The unconscious wish to own and rule the child is but a revival of the infantile wish to incorporate the love-object in order to have sole possession of it.

The unconscious wish for monopoly is dangerous either from the side of the *id* or from the side of the *super-ego*.

53. A contribution to the study of manic-depressive psychosis.

I. LATIF, Lahore.

Clinical material from a case history is presented to bring out certain aetiological factors in the genesis of this specific form of cyclic insanity.

54. Symbolic significance of the lice.

I. LATIF, Lahore.

Material from two clinical cases is interpreted to bring out the meaning of the lice-symbolism. The interpretation was followed by therapeutic results in both the cases.

SECTION OF ENGINEERING

President:—A. H. Pandya, Sc.D. (Eng.), A.M.Am.Soc.C.E., A.M.I.Struct.E., A.M.I.E., A.M.Inst.W.

1. The synopsis of the article on shipbuilding and its possibility in India.

D. L. Neogy, Bhavnagar.

While wood was the only building material for ships, India had a flourishing shipbuilding industry. With the advent of shipbuilding in iron and then in steel the Continent of Europe and Great Britain developed the industry to the present high standard; while India lagged behind.

To develop this nationally important industry it is necessary to study the different methods of operation as practised both on the Continent of Europe and in Great Britain. The Continental building practice differs from that of Great Britain in some methods of operation and a study is required to ascertain to what extent these different methods may be adopted successfully in India. Institutions for training Naval Architects and Marine Engineers are required to be established while laboratories to test models of ships for stability, propulsion, etc., are also urgently needed.

The general survey of the present Indian shipbuilding industry shows very little progress made during the last twenty years or more and unless machines for propulsion are manufactured in India, it is doubtful whether the building of hulls alone can establish this industry profitably.

2. Flow of fluids through beds of granular materials.

C. Venkata Rao, Waltair.

The general problem of fluid flow through beds composed of solid particles has received a good deal of attention and critical study due to its importance in the design of packed absorption towers and of converters containing granular catalysts, in the passage of liquids through filter cakes and in the calculation of the movement of ground waters, of petroleum, and of natural gas through sand and rock, in deciding the extent of seepage through the subsoil of dams and of large buildings and in determining the permeability of concrete and other building materials. The flow concepts developed so far have been either (1) the concept of flow through parallel capillaries, or (2) flow through orifices with a series of enlargements and contractions. Investigations in this important field fall into two categories: one category dealing with two or more variables and correlating these by an empirical equation which holds only for the specific case and the other category dealing with a more general and fundamental relationship which governs the flow of fluids in smooth straight pipes. The latter attempts are mainly directed towards evolving modified equations of Poiseville or of Fanning. Introduction of dimensionless groups by Blake has greatly facilitated progress.

In the present paper the author deals with the work done by him on the flow of heavy oil through beds composed of definite mixtures of graded sizes of calcite particles with a view to evolving a more generalized formula for granular beds of broken or crushed material of random packing which are so widely used in industrial operations. Since the last eight years a good deal of work has been done in the Chemical Engineering Laboratories of the Imperial College of Science and Technology, London, under the direction of Prof. S. G. M. Ure.

3. Refrigeration in cold storage of potatoes.

B. B. GHOSH, Calcutta.

The problem of storing produce for a period between the time it leaves the hands of the producer and the time it reaches the consumer occupies to-day a pivotal position in the general economy of the world's food supplies. Of all vegetables grown in India, the potato is perhaps the only one stored and marketed on a very extensive scale, and being a seasonal crop, storage forms the most important part of this extensive commerce. Potatoes being a perishable commodity, heavy losses occur in storage and during the process of marketing.

Storage should provide the proper conditions for preserving the natural quality of the potato for table purposes, and also should preserve its vigour for seed purposes. Before storing, potatoes should be carefully graded and sized and defective ones removed.

Any of the common materials of construction may be used in the construction of the building provided the interior of the room is of odourless material and moisture proofing is specially important for the insulation. In any consideration of the storage of potatoes, it should be remembered that they 'breathe' like human beings, consuming oxygen and throwing off carbon dioxide and moisture.

The refrigerating problem divides itself into two major parts: (1) pull down, and (2) holding. The designing of the refrigerating plant by the method of daily loading will result in saving in cost by about 50% as compared to that required by the usual method of bulk loading and then starting the plant.

4. Tests of cement-surkhi mortars under various conditions.

K. RAMANUJACHARI, Hyderabad-Deccan.

Surkhi of three different grades—under-burnt, well-burnt and over-burnt—has been added to cement mortars (1 : 3, 1 : 4, 1 : 6) in different proportions from 0 to 50%. Experiments are being conducted to find out how the strength of mortars is being effected by the addition of surkhi at different ages. Two brands of cement have been used. Tests in Tension, Compression and Adhesion have been carried out and interesting results obtained.

5. Methylated spirits as fuel in petrol engines. Part 2.

G. RAMARAO, Hyderabad-Deccan.

By completely choking the air and a little vigorous cranking the engine starts quite easily without the aid of petrol as in the previous trials. Interesting results are obtained with mixtures of spirits and castor oil, spirits and camphor, and other mixtures.

Proceedings of the Twenty-ninth Indian Science Congress

PART IV—LATE ABSTRACTS, ERRATA AND ADDENDA, DISCUSSIONS, LIST OF MEMBERS AND INDEX

CONTENTS

1. LATE ABSTRACTS

Section I, Mathematics and Statistics.

34. The average number of unrestricted partitions of a large number.

S. Chowla *and* F. C. Auluck, Lahore.

If $p_m(n)$ denotes the number of partitions of n into exactly m parts, for what value of m is $p_m(n)$ maximum? We find that there exist positive constants A and B such that $p_m(n)$ is maximum when

$$A \frac{n^{\frac{1}{2}}}{\log n} < m < Bn^{\frac{1}{2}} \log n.$$

Defining the average value of $p_m(n)$ as

$$\frac{\sum_{m=1}^{n} mp_m(n)}{p(n)}$$

it is shown that this expression lies between $A \dfrac{n^{\frac{1}{2}}}{\log n}$ and $Bn^{\frac{1}{2}} \log n$.

35. The application of matrices to the solution of normal equations.

U. Sivaraman Nair, Trivandrum.

The solution of normal equations together with the proper checks in numerical work is given in the form of determinants in books on the Theory of Errors. The application of matrices reduces the solution to an elegant form. In the present paper, we give the actual solution and a few results on the standard errors of the observations and the co-variances of the estimates.

Thus, the observations are put as

$$(a)(X)-(L) = (U) \quad \ldots \quad \ldots \quad (1)$$

and the normal equations as

$$(A)(X) = (a')(L)$$

where

$$(A) = (a')(a).$$

The solution is therefore

$$(X) = (A^{-1})(a')(L).$$

The standard error of the observations is

$$\mu^2 = (L')\, I-(a)(A^{-1})(a')\, (L) \div (n-k).$$

The Matrix of co-variances is

$$(\rho) = \mu^2\, (A^{-1}).$$

It will be evident that the forms for the several results do not require any particular check. The expressions for μ^2 and (ρ) are also new.

36. Perpetual Civil Calendar.

H. SUBRAMANI AIYAR, Trivandrum.

The calendar is devised in the form of three tables, and a date slide and month roller, with a slot through which can be seen the week days for any month. These week days are arranged in a square below the movable date slide.

Table I contains in four columns all the century numbers, and Table II contains all the years of any century arranged in seven rows. Table III contains the twelve months and letters representation for the seven week days in different permutations in which they can occur.

The column for the different months and the week day for any date in them are fixed by the well-known principle that, January and October ; February, March and November ; September and December ; April and July, begin with the same week day in any ordinary year, as the number of days in the interval between the specified months is a multiple of seven. If the year under consideration happens to be a leap year, February and August ; April, July and January will have the 1st of a month on the same week day.

37. On the equation $a^X - b^Y = b^y \pm a^x$.

S. S. PILLAI, Trivandrum.

In two previous papers I have proved that the equation

$$a^X - b^Y = c$$

has only a finite number of solutions for any c and at most one solution when c is large. These two results together mean that the equation

$$a^X - b^Y = a^x - b^y$$

has only a finite number of solutions.

In this paper I prove that the equation

$$a^X - b^Y = b^y - a^x$$

has only a finite number of solutions in x, y, X and Y.

In this connection I put a conjecture given before in the following form:—

Arrange all the powers of integers in ascending order as follows:—

1, 4, 8, 9, 16, 25, 27, 32, 36, 49, 64, 81, 100, 121, 125, 128, 144, . . .

Let a_n stand for the nth member of the above sequence,

then $$\lim (a_n - a_{n-1}) = \infty .$$

Section II, Physics.

52. The relation of gas pressure to radiation pressure in Bose-Einstein assembly.

B. N. SINGH, Delhi.

The relation of gas pressure to radiation pressure in a Fermi-Dirac gas has been studied by Kothari and Singh. In this paper we have extended the discussion to the Bose-Einstein gas.

It has been found that when, δ, the ratio of gas pressure to radiation pressure is less than unity the gas is necessarily non-degenerate but the converse is not true, i.e. in a non-degenerate gas δ may be less than or greater than unity. In degeneracy on the other hand δ must be greater than unity in the non-relativistic case, whereas in the relativistic case it is equal to unity.

The results are thus similar to those obtained for the Fermi-Dirac gas with one important difference, viz. in the relativistic degenerate case the two pressures are always exactly equal. This is to be expected since black body radiation obeys Bose-Einstein statistics.

53. Some observations in the Whispering Gallery of the Gol Gumbaz, Bijapur.

H. J. TAYLOR, Bombay.

An extension of Rayleigh's theory of whispering galleries suggests that the intensity of sound in the gallery should vary radially. If the source is at a distance x from the wall, the maximum of intensity should also be at the same distance x from the wall. The simple geometrical theory indicates no circumferential maximum, but enables one to calculate approximately the intensity to be expected at the point of the gallery opposite the source.

In the gallery of the Gol Gumbaz, 124′-5″ in diameter, the radial maximum can be observed with ease, using intermittent sounds such as the tick of a metronome. An observer not knowing the position of the source can locate the maximum with an error not greater than 2 feet. The maximum occurs at a distance from the wall equal to that of the source, and the width of the gallery enables distances up to 11 feet to be used.

There is also a very marked circumferential maximum at the point exactly opposite the source, which is so sharp that it can be located by ear with an error not usually greater than 1 foot. The intensity of sound at the maximum is much greater than the simple theory suggests.

These properties are due to the fact that the dome of the Gol Gumbaz is almost a perfect hemisphere, and the gallery is not far below the diametral plane. The transmission of sound is therefore not confined to the horizontal plane. All great circles through the source represent possible paths, and as these converge at the opposite point, the existence of a sharp maximum, and the great intensity found there, are thereby explained. These features of the Gol Gumbaz are worthy of note, since the building is acoustically probably unique.

Section III, Chemistry.

213. Glucose dehydrogenase from germinating green gram (*Phaseolus radiatus*).

K. P. BASU *and* J. N. KARKUN, Dacca.

Our studies have revealed the presence of an enzyme in germinating green gram which can act on glucose. It is found to be a dehydrogenase acting on glucose both aerobically (optimum pH 6·5) and anaerobically. Aerobic oxidation is inhibited by HCN, H_2S, sodium pyrophosphate, sodium fluoride, etc., while the anaeorbic oxidation is inhibited by narcotics to the extent of about 70%. The enzyme cannot decolourise methylene blue anaerobically but it can use higher oxidation-reduction potential dyes like 2 : 6-dichlorophenol indophenol and also quinone as hydrogen acceptors. Carriers such as flavin, adrenaline, ascorbic acid do not accelerate the absorption of oxygen, whereas glutathione accelerates the process by about 8%. The enzyme acts on glucose with the formation of acid (gluconic acid). Galactose and mannose also undergo dehydrogenation in presence of this enzyme preparation while xylose and arabinose are not acted on. Fructose is acted on to a slight extent. Precipitation by alcohol (70%, 80%, 90%), acetone, alcohol-ether mixture failed to give active preparation. The enzyme seems to be absorbed to some extent on kaolin, but no satisfactory method of elution has yet been found. No coenzyme has been detected.

214. Phytase from germinating *Cicer arietinum* (Bengal gram).

K. P. BASU *and* K. MUKHERJEE, Dacca.

An active phytase preparation has been obtained from germinating Bengal gram by extraction with chloroform water mixture and precipitation with alcohol-ether. Its optimum pH for cleavage of both phytin (natural) and sodium phytate lies between 5·4–5·6. Its action is inhibited strongly by sodium fluoride and slightly by vitamin C and no acceleration was obtained with calcium, magnesium and manganese ions. It does not require a coenzyme. Optimum temperature for its action was found to lie between 45°–50°C. The energy of activation is about 11,000 calories. Optimum concentration for cleavage of sodium phytate is about 0·06 molar which is also the optimum concentration for acid glycero-phosphatase.

The same preparation was found to liberate inorganic phosphate from glycerophosphate. By studying the effect on both the substrates, glycerophosphate and phytate individually and together at their optimum concentrations, it was ascertained that enzymes for breaking phytate and glycerophosphate were different. Sodium oxalate inhibits the hydrolysis of sodium glycerophosphate but has no effect on phytate hydrolysis.

215. Preparation of vitamin B_1 concentrate from rice bran.

Y. V. S. RAU, Bangalore.

The vitamin B_1 content of good quality rice bran has been estimated by the thio-chrome method according to the procedure of Murty and Rau (*Curr. Sci.*, 1941, **10**, No. 3) and found to contain between 1 and 1·5 mg. per 100 g. Several methods for the extraction of vitamin B_1 from rice bran have been tried. Maximum extraction of vitamin B_1 is obtained using 0·5N hydrochloric acid and shaking for one hour. The vitamin B_1 so extracted has been adsorbed on norit (optimum pH 5) and eluted with dilute acid. The eluate so obtained contains about 60 to 80% of the vitamin B_1 that has been extracted from the rice bran. Experiments on a small scale are being tried with a view to prepare vitamin B_1 concentrates of high potency fit for oral administration.

216. Diastatic enzymes for micro-organisms. II.

S. SREENIVASA RAO *and* B. N. SASTRI, Bangalore.

An examination of more than 100 cultures of micro-organisms which grow on a starch medium (taken from the National Collection of Type Cultures) has shown that highly active sources of diastase are to be found either in the *Asp. flavur oryzae* group among fungi or in the *Mesentericus* and *Subtilis* groups among bacteria.

The cultural conditions of a strain of *Asp. oryzae* and of a strain of *B. mesentericus* for maximum enzyme production were studied in some detail. It was found that diastase production was greatly influenced by the source of nitrogen. Thus, giving a value of 100 for diastase production by *Asp.. oryzae* (sp.?) under certain conditions, the diastase produced by the same organism under identical conditions of temperature and pH, but with Witte's peptone as the source of N is represented by 65·3. The corresponding values with ammonium chloride, sodium nitrate, asparagine and urea as sources of nitrogen are respectively 12·0, 35·0, 32·0 and 56·5, the nutrients being supplied on equal nitrogen basis.

Considerable variations in diastase production are obtained with different peptones. Thus the values obtained with bactopeptone and silk peptone are 70·4 and 100·0 respectively.

217. High temperature fermentation. Part I.

B. N. SASTRI *and* M. SREENIVASAYA, Bangalore.

In view of the importance of thermophilic organisms in the industrial fermentation of highly resistant celluloses and proteins, a number of organisms were isolated from garden soil and fermenting groundnut cake. The isolations were carried out in a liquid medium of malt extract, a temperature of 60°C being maintained during the process. Four specific bacteria have been thus isolated. Their cultural, morphological and physiological characteristics have been determined. One of them has been found to digest fibrin rapidly at 50°–60°C to the extent of 75% and can be employed in the preparation of peptones and in the extraction of oils from oil bearing seeds.

218. Co-ordination compounds. Derivatives of members of the Naphtol AS series.

R. N. MAJUMDAR, V. B. THOSAR *and* K. VENKATARAMAN, Bombay.

Following the previous investigation, the suitability of metallic co-ordination compounds of nitroso naphthols as pigments for oil paints, and with regard to the behaviour of differently constituted naphthols in the reactions involved, various Naphtols were nitrosated and their metal co-ordination compounds prepared. The Naphtols used included Naphtol AS-BO (the *d*-naphthalide of β-hydroxynaphthoic acid), Naphtol AS-SW (the β-naphthalide of β-hydroxynaphthoic acid), Naphtol AS-ITR (the 3-chloro-4-6-dimethoxyanilide of β-hydroxynaphthoic acid), Naphtol AS-BO (the *m*-nitroanilide of β-hydroxynaphthoic acid) and Naphtol AS-G (diacetoacetic tolidide). The commercial Naphtols were carefully purified and their purity established before use.

Owing to the comparatively low solubility of nitroso derivatives of Naphtols in alcohol, the preparation of the lakes was carried out by a one step process, nitrosating the Naphtols in presence of metallic salts. The alcoholic Naphtol solution was refluxed and treated in succession with the relevant metallic salt solution in alcohol, glacial acetic acid and a concentrated aqueous solution of sodium nitrite. Iron, copper, cobalt and nickel salts were used for the preparation of these co-ordination compounds of the nitroso Naphtols. It was found in general that two atoms of iron were linked to 3 mols. of nitroso Naphtol, one atom of cobalt to 3 mols. of nitroso Naphtol, and one atom of nickel to 2 mols. of nitroso Naphtol. In the case of copper, the results varied according to the naphthol used; with some Naphtols one atom of copper was linked to one, and with others to 2 mols. of the nitroso Naphtol.

219. Studies in the Naphtol-AS series. Synthesis of Naphtols with paraffin chains.

R. V. BHAT, S. R. RAMACHANDRAN *and* K. VENKATARAMAN, Bombay.

While the present experiments are part of a general study of the chemistry and tinctorial properties of the Naphtols, the synthesis is based on considerations regarding the constitutional character of a naphthol that is likely to be favourable to good rubbing fastness. Two factors play a dominant role in determining the rubbing fastness of an azoic dyeing. One is the substantivity of the naphthol, since it is the azoic dye derived from that portion of the naphthol not substantively adsorbed, but mechanically retained by the yarn, that is responsible for the rubbing off effect. The other is the efficiency of the removal of this azoic dye by the soaping after-treatment. In an attempt to take both of these factors into account the constitution of a naphthol has been so modified that good substantivity is obtained and the reagents (such as soaps and other detergents) employed in the after-treatment possess a certain solvent or emulsifying action towards the azoic dye precipitated on the fibre.

By condensing *o*-, *m*-, and *p*-acylamidoaniline with 2-hydroxy-3-naphthoic acid, a series of Naphtols were obtained, possessing the features of a second carboxyamide group and an aliphatic chain of 8–16 carbon atoms, and their dyeing and fastness properties were studied by the methods elaborated in earlier paper.

The substitution of the aliphatic chain in the *p*-position in the arylamide half of the naphthol component was advantageous in comparison with the *m*- and *o*- positions. The dyeings from the *p*-substituted naphthols were characterized by depth of shade, brilliance and excellent fastness to rubbing, kier-boiling and light, while those from the *m*- and *o*- substituted naphthols were weak and, though exhibiting good fastness to rubbing, were only moderately fast to other agencies.

220. The dyeing of khaki on cotton.

S. R. RAMACHANDRAN *and* K. VENKATARAMAN, Bombay.

'Khaki' has become more or less synonymous with mineral khaki produced by precipitating on the fabric oxides of chromium and iron, although substantive, sulphur and vat khakis are also normally available. The reason is the outstanding fastness, specially to light, of mineral or chrome khaki. To produce successful results, the operations of scouring, padding, drying in a suitably designed hot air flue, and precipitation with caustic soda have to be carefully controlled. The quantity of chromium used is large, varying from 12–20% in terms of sodium or potassium dichromate.

'Vegetable khaki' has recently been exploited to a considerable extent on account of the scarcity and high cost of bichromates. Advantage is taken of the known behaviour of tannins towards iron and copper salts, followed by dichromate oxidation. In conjunction with iron and copper salts the tannin material in vogue is myrobalan extract, and to a smaller extent tannic acid itself. A method widely used consists in padding the fabric through a concentrated extract of myrobalan in water, drying, and re-padding through a solution of ferrous sulphate, followed by working in a boiling solution of sodium bichromate, washing and soaping. The result is a greenish khaki of reasonable light fastness (grade 4-5) and moderate washing fastness, but very poor fastness to perspiration or acid. Problems in handling tannins on the large scale would be their susceptibility to produce stains in contact with iron parts of machinery and difficulties in obtaining uniform results from batch to batch.

Utilizing the polygenetic character of catechu, a method has been developed for the production of khaki and allied shades on vegetable fibrous materials. The shades obtained are characterized by uniformity and close similarity to mineral khaki dyeings, with which the fastness properties also are quite comparable. The essential feature of the process is the use of cutch, chromium and iron salts in a single bath, which is buffered with sodium acetate; the padded cloth is steamed in a Rapid Ager, and after-treated with an oxidizing agent such as bichromate or chlorine. The concentration of chromium involved is much lower than for mineral khaki, and a hot flue is not required.

221. Adsorption studies in colour lake formation.

R. N. Majumdar, T. N. Mehta *and* K. Venkataraman, Bombay.

Bancroft and Farnham (*Jour. Phys. Chem.*, 1932, **36**, 3127) in their study on 'Alumina Lakes' have shown that alizarinic acid and the acid of orange II form a chemical compound of the type AlX_3 with alumina. With a view to study the course of the formation of adsorption complexes of sodium orange II with aluminium hydroxide under different conditions, chemically pure sodium orange II was treated with aluminium hydroxide formed from aluminium chloride and sodium carbonate, by one step and two step processes. In the two stage process aluminium hydroxide was precipitated from an aluminium salt and sodium carbonate, and the dye solution immediately added. After a definite period, the reaction mixture was filtered, and from the concentration of the filtrate, the adsorption calculated. In the one step process sodium carbonate solution was mixed with the dye solution, and aluminium salt solution added to this mixture, aluminium hydroxide being precipitated in presence of the dye solution. It was found that there was appreciable difference in the amount of the dye adsorbed by the same quantity of aluminium hydroxide in the two processes, a much greater amount of dye being adsorbed in the single stage method. This observation was of interest from the point of view of the staining power of the lakes produced. The adsorption of the dye by aluminium hydroxide prepared as above was always modified by the presence of electrolytes, concentration of the dye solution, and the amount of substrate produced. The effect of dye concentration was studied by varying it, and maintaining the quantity of aluminium hydroxide constant. The electrolytes studied were sodium chloride and sulphate, which had opposite effects in low concentrations. The effect of temperature and of time of contact between substrate and dye solution on the amount of the dye adsorbed were also examined. Similar adsorption studies were then made on barium sulphate and lead sulphate.

On the basis of previous work in this laboratory on the fastness to light of dyes on textiles and coloured cements, the standardization of light fastness was carried out in the case of the pigments used in paints and varnishes.

222. Wetting agents. Ethanolamide sulphates.

S. I. Taraporewala *and* K. Venkataraman, Bombay.

The properties (Herbig number, flotation, calcium soap dispersing and Congo rubine number) of paraffin chain acyl ethanolamide sulphates have been studied in comparison with oleyl-N-methyltaurine, using for the acylation of monoethanolamine, caprylic, capric, lauric, myristic, palmitic and stearic acids. The solubility in water decreased as the length of the carbon chain increased. Sodium caprylyl ethanolamide sulphate gave a turbid solution at 0·25% concentration at room temperature, the capric and lauric acid derivatives gave clear solutions at 40°C., while the myristic, palmitic and stearic acid compounds were soluble only at 60°C. The wetting power of the whole series was therefore determined at 60°C. The Herbig number rose from caprylic to a maximum for the lauric acid derivative, and the wetting power then diminished in the case of the myristic and palmitic acid analogues, rising again for the stearic acid compound. The capric and lauric acid derivatives had a Herbig number higher than that of oleyl N-methyltaurine. In the case of the sodium salts of saturated fatty acids, the Herbig number increased with the length of the alkyl chain from C_6 to C_{12}, and then it decreased continuously down to C_{18} at concentrations below 0·25%. At 0·25% concentration, however, the maximum was reached at C_{14}. The flotation or sinking time results were in general confirmatory of the Herbig numbers, except that the positions of sodium stearyl ethanolamide sulphate and sodium palmityl ethanolamide sulphate were reversed at 0·1% concentration. By this method also the capric and lauric acid compounds proved to be better wetting agents than oleyl N-methyltaurine. The calcium soap dispersing power of the present compounds was comparatively low. The lauryl compound had the highest hard water resistance in the series, but it was markedly inferior to oleyl N-methyltaurine. The Congo rubine number could not be determined, since the compounds salted out on the addition of sodium chloride.

223. Protective colloidal power and detergency.

S. I. TARAPOREWALA *and* K. VENKATARAMAN, Bombay.

With reference to the view of Zakarias on fat-free detergents and the suggested relation between protective colloidal action and detergency, scouring experiments in a launderometer were undertaken with a series of textile auxiliary agents, using standard soiled cloth. The efficiency of scouring was followed by wax content, whiteness, and wettability determinations on the treated fabric. Of the nine commercial products examined, sodium lauryl sulphate exhibited the highest detergent power, and sodium dioctyl sulphosuccinate, a synthetic polymer free from ionizing groups, the sodium salt of oleyl N-methyltaurine, a sodium dialkylnaphthalene sulphonate, a mixture of terpene derivatives, a secondary alkyl sulphate, Turkey Red oil and a highly sulphonated castor oil were in order of diminishing efficiency. This order could not be correlated with the protective colloidal power of the products, two of which with excellent cleansing action behaved as noncolloidal electrolytes, so that the Congo rubine number could not be determined.

Among the soaps, sodium laurate was the most effective detergent. Sodium tetrahydroanacardate was almost entirely devoid of cleansing power. Since the Congo rubine numbers for the sodium salts of stearic, anacardic and tetrahydroanacardic acids could not be observed, it was not possible to correlate these with detergency. Although the order of diminishing protective colloidal power was sodium oleate, sodium linoleate and sodium laurate, the detergent power was in the reverse order. Of the three soaps, sodium stearate, oleate and linoleate, each containing 18 carbon atoms, the detergent power increased with the increase in unsaturation.

The detergency of triethanolamine soaps of lauric, oleic, linoleic, and rininoleic acids decreased in the order named, when wax content was taken as the criterion. The Congo rubine numbers for these compounds were not obtainable, as they salted out on adding sodium chloride. Increased unsaturation did not improve detergent power, and the presence of a hydroxyl group was not a favourable factor.

224. The effect of increasing concentrations of alkali in kier-boiling.

NAZIR AHMAD, S. M. KAJI *and* K. VENKATARAMAN, Bombay.

Commercial single 20's yarn from Indian cotton was boiled with progressively increasing quantities of caustic soda (1–10% on weight of material) in an experimental kier at 15 lbs. pressure for 6 hours. The samples were then bleached, estimating the chlorine consumption, and the measurable qualities of the treated yarns, such as loss in weight, copper number and cuprammonium fluidity determined. As anticipated, the copper number did not indicate any marked differences, since any reducing constituents would be dissolved in the alkaline lye and removed. The consumption of chlorine decreased in a regular manner with increase in the quantity of caustic soda used in kier-boiling. Thus it fell from 0·77% for the 1% caustic soda boil to 0·46% for 10% caustic soda. The cuprammonium fluidity determinations gave interesting results. Plotting fluidity against concentration of caustic soda, the curve did not represent a linear relationship, but sharp maxima and minima. In the case of the bleached samples, the fluidity increased till the concentration of caustic soda reached 3%, decreased at 4% concentration, after which it began to rise till a maximum was reached at 6% caustic soda. A sharp decline was noticed at 9% caustic soda strength. The fluidity figures for unbleached yarn gave a similar curve.

The experiments were repeated using 1–10% soda ash. The chlorine consumption fell from 1·83 for 1% soda ash to 0·56% for 10%. The fluidities of the bleached samples, instead of rising as in the case of caustic soda with increasing concentration up to 3%, diminished with increasing concentration of soda ash till a minimum was reached at 3%. The values then alternately rose and fell at 4, 5 and 7% soda ash at which a maximum identical with the maximum fluidity value at 6% strength of caustic soda was attained. At 9% concentration of soda ash, a sharp decline was again noticed, and the value was very near the minima. The fluidity curve for the unbleached yarn was nearly identical.

In a third set of experiments, yarn was boiled in an open kier with 1–10% soda ash at 160°–170°F. for 6 hours, and bleached. The curve was similar in shape to the soda ash boil curve, except that the actual fluidity values obtained were much lower. The consumption of chlorine was practically constant throughout, being 2·09% for 1% soda ash and 1·95% for 10%. The fluidity results indicate in general that, if precautions to exclude oxygen, metallic catalysts, etc., are taken, increasing amounts of caustic soda or soda ash do not necessarily lead to damage, but that there are optimum concentrations, on either side of which degradation of the cellulose might occur.

225. *Sterculia urens* gum in finishing and printing.

V. C. Patwardhan *and* S. R. Ramachandran, Bombay.

This belongs to the class of Karaya gums and is indigenous to the Bombay Presidency and the Central Provinces. It is somewhat similar in appearance to gum Tragacanth and is known as Indian gum tragacanth. Tschirch and Flück, and Middleton and Rowson have studied its utility as a substitute for gum tragacanth in shampoos and other toilet preparations. They found that it could form an effective substitute for gum Tragacanth. An attempt has now been made to study its utility in finishing and printing with a view to replacing, partly at any rate, gum tragacanth which has entirely to be imported and whose cost has increased considerably. Determination of ash, moisture, acidity, viscosity and keeping properties of this mucilage has been made in comparison with a standard sample of gum tragacanth. While the ash, moisture and viscosity (the latter at a slightly higher concentration) approximate to that of gum tragacanth, the acidity of *Sterculia urens* would appear to be rather high. Although this could be reduced by the addition of mild alkaline agents, such as borax, to the same level as tragacanth, this addition would seem to be unnecessary as the acidity would in itself be an advantage in preparing a mucilage with this gum for printing purposes by certain methods. Additions of caustic soda, tannic and acetic acids, and metallic salts like chromium acetate do not appear to have any adverse action in optimum concentrations.

226. Production of khaki shade from vegetable raw material.

J. L. Sarin, Lahore.

A khaki shade for military requirements has been produced from locally available vegetable raw materials. The dye bath is prepared by extracting with water (200 parts), main (*Tamarix dioca*) 50 parts, naspal (5 parts) and pomegranate rind (25 parts). The shade obtained is mordanted by successfully dipping the cloth in a bath of ferrous sulphate

(½ part), copper sulphate (1 part) and potassium dichromate (5 parts) in water (200 parts). The material produced was sent to the Inspectorate of Ordnance and Clothing, Cawnpore and has been approved.

227. Studies in mixed photosensitizers.

G. GOPALA RAO, Waltair.

In previous publications from the author's laboratories, the photosensitized oxidation of ammonia in aqueous solution with ignited titanium dioxide as photosensitizer has been studied and the mechanism of the reaction discussed. It was found that titanium dioxide is an excellent photosensitizer for this reaction in light transmitted by glass. Likewise it was found that zinc oxide is a good photosensitizer. Recently, it was noticed that a simple mixture of the two oxides has much less photosensitizing activity than what the mixture law would suggest. If the two oxides are ignited together, the photosensitive properties disappeer almost completely. This phenomenon has been studied and discussed in the present paper.

228. Photosensitization by ceric oxide.

G. GOPALA RAO, Waltair.

Ceric oxide was prepared by precipitating cerious oxide and oxidizing the same with hydrogen peroxide. It was then washed well to free it from excess of alkali and adhering electrolytes. The ceric oxide was ignited at 800°C and used in the experiments. It was found to photosensitize (1) the oxidation of aqueous ammonia to nitrite, and (2) the decomposition of silver nitrate in sunlight.

229. Studies in some inorgano-organic gels.

MATA PRASAD *and* G. S. HATTIANGADI, Bombay.

The time of setting 't' of potassium stearate gels in pinene containing different amounts of the soap, 'A', has been measured by Fleming's method at various temperature 'T'. It has been found that the graphs (i) of the values of log A plotted against log t, and (ii) of the values of log t plotted against $\frac{1}{T}$, are straight lines.

The cooling curves of the gels of sodium palmitate, potassium oleate and potassium stearate have been studied at different temperatures during the sol-gel transformation. It is observed that when the concentration of the gel-forming substance is increased, the initial temperature goes on decreasing; again the temperature at which the gel sets is slightly higher than that to which the gel-forming mixture is cooled, and this decreases with a decrease in the concentration of the gel-forming substance.

Viscosity measurements of sodium stearate gels in pinene during sol-gel transformation were carried out by the Falling Sphere method, at different temperatures, using different concentrations of the soap. When the values of log $(\eta-\eta_0)$, are plotted against 't', straight lines are obtained and it is noted that these straight lines for different soap contents are nearly parallel to one another.

230. Condensation of *o*- and *p*-chloro- and *m*-bromo-benzaldehydes with malonanilic acid.

K. C. PANDYA *and* (MISS) RASHMI BALA PANDYA, Agra.

Following the condensations of various aldehydes with malonanilic acid in the presence of a trace of an organic base like pyridine or piperidine, reported in earlier papers (Mehra and Pandya, *Pro. Ind. Acad. Sci.*, 1938, **7**, 369; 1939, **9**, 509; Ittyerah and Pandya, *ibid.*, 1941, **13**, 119; 122; 641) further condensations are studied here with chloro- and bromo-benzaldehydes.

The results are in a line with the earlier observations. When pyridine or piperidine is used in a trace, condensation as well as decarboxylation takes place, and the *p*-chloro-, *o*-chloro- and *m*-bromo-cinnamanilides are obtained with or without the acids. The yields are sometimes very near to the theoretical, and this may be due partly to the pyridine-trace method and partly to the presence of the chlorine or the bromine atom on the aldehyde molecule, which has been found by us to accelerate condensations with malonic acid and give almost theoretical yields (Pandya and Miss Pandya, *ibid.*, 1941, **14**, 112). It is peculiar that the *o*-chloro- and *m*-bromo-cinnamanilides are formed in two isomeric forms with distinct melting-points.

In the absence of any base or of any other catalyst, condensation is slow, but gives the corresponding chloro- or bromo-benzalmalonanilic acids, with or without some cinnamanilide.

231. Fatty acid composition and glyceride structure of the fat from the seeds of *Vateria indica*.

C. VENKTA RAO *and* M. NARASINGA RAO, Waltair.

The fat from the seeds of *Vateria indica* contains 92·6% insoluble mixed fatty acids composed of 60·7% solid acids and 39·3% liquid acids. The composition of the fatty acids is found to be 0·2% lower acid (probably C_{10} acid), 0·7% myristic acid, 13% palmitic acid, 43·1% stearic acid, 0·4% arachidic acid, 42·5% oleic acid and 0·1% linolic acid. The non-saponifiable matter is mainly composed of sito-sterol and a trace of another sterol whose bromo-acetate melts at 120–123°C. to a dark coloured liquid. Further, the fat on steam distillation yields 0·05% of a terpenoid oil having an iodine value of 148. The neutral fat contains 2·5% fully saturated glyceride mainly composed of tri-stearin (m.p. 71°C.). Further work on the glyceride structure of the fat is in progress.

232. Molecular rearrangement of *o*-acyloxy-acetoarones to *o*-hydroxy (diacyl) methanes. Part I.

V. V. VIRKAR *and* R. C. SHAH, Bombay.

In continuation of the previous work (*Curr. Sci.*, 1938, **3**, 107; *J.C.S.*, 1939, 1679) the sodium method has been further applied for the transformations of *o*-aroyloxy acetoarones and *o*-acoyloy acetoarones to respective *o*-hydroxy-B-diketones for the syntheses of 2-naphthyl chromones and 2-alkyl chromones. The method has been found to be useful for the synthesis of chromones in general.

A number of 2-naphthyl chromones have been prepared by applying the method to naphthoyloxy derivatives of *o*-hydroxy acetoarones.

Baker (*J.C.S.*, 1933, 1382) could not transform resacetophenone diacetate or 4-*o*-benzoyl-2-*o*-acetyl resacetophenone but metallic sodium brings about the molecular rearrangement in these and similar substances and the method has therefore been successfully applied for the syntheses of a number of 2-alkyl chromones.

233. Molecular rearrangement of *o*-acyloxy-(aceto-arones) to *o*-hydroxy-(di acyl) methanes. Part II.

V. V. VIRKAR *and* R. C. SHAH, Bombay.

Various reagents, such as anhydrous potassium carbonate in presence of dry benzene or dry toluene (*J.C.S.*, 1933, 1381; 1934, 1953) sodamide in dry ether (*Curr. Sci.*, 1933, **2**, 214; *J.C.S.*, 1934, 1767; 1935, 866), alcoholic sodium ethoxide (*J.C.S.*, 1940, 1499) and metallic sodium in presence of dry ether, dry benzene or dry toluene (*Curr. Sci.*, 1938, **3**, 107; *J.C.S.*, 1939, 1679), have been used previously to bring about the molecular rearrangement in *o*-aroyloxy aceto arones. It has now been found that many other reagents can be successfully used for the migrations of the above type. Various reagents, such as potassium or sodium carbonate in presence of alcohol, sodium bicarbonate in presence of alcohol, aqueous or alcohol alkali in presence of alcohol or any other suitable solvent, aqueous hydrated barium oxide in presence of alcohol have been successfully used for the migration of *o*-aroyloxy group.

Moreover a comparative study of all these available reagents have been made on compounds actually examined by previous workers and also on compounds tried by metallic sodium method.

234. Molecular rearrangement of *o*-aroyloxy-aceto-arones containing nitro-group to the corresponding *o*-hydroxy diacyl-methanes. Part III.

V. V. Virkar *and* R. C. Shah, Bombay.

It has been observed that no migration of *o*-aroyloxy group takes place if a nitro group is present in the aceto arone nucleus. But migration takes place as usual if a nitro-group is present in the aroyloxy radical. Few nitro flavones containing the nitro-group in the 2-phenyl group have thus been prepared by this method.

235. Synthesis of quinoline derivatives.

T. B. Desai *and* R. C. Shah, Bombay.

A number of new quinoline derivatives 2-phenyl-4-hydroxy-3-acetyl quinolines variously substituted in the benzene nucleus have been synthesized through the condensation of various imidochlorides from benzoyl derivatives of substituted anilines with ethyl sodio-aceto-acetate by the method of Limaye and Shah (*Sc. Cong. Abst.*, 1940).

236. Synthesis of quinoline derivatives.

K. D. Kulkarni *and* R. C. Shah, Bombay.

A number of anilide-imido-chlorides derived from substituted benzoic acids have been condensed with ethyl sodio-malonate by the method of Heeramaneck and Shah (*J.C.S.*, 1936, 428). From these experiments, generalization has been drawn regarding the effect of the substituents in the benzoic acid nucleus on the condensation. The condensation products have been further cyclised to the corresponding 2-phenyl-4-hydroxy-3-carbethoxy-quinolines, substituted in the 2-phenyl group.

237. 2 : 4-dihydroxy-3-acetylbenzoic acid.

N. B. Parekh *and* R. C. Shah, Bombay.

The Fries transformation of 4-*o*-acetyl-B-resorcylic acid and its methyl ester was studied in order to find out whether the acetyl group migrated to the B-position or the Y-position. The products obtained were found to be 5-acetyl-2 : 4-dihydroxy benzoic acid and its methyl ester respectively showing that migration had taken place to the B-position. The isomeric 2 : 4-dihydroxy-3-acetyl benzoic acid which would have been formed if the migration had taken place to the Y-position has been conveniently obtained by the action of potassium bicarbonate on 2-acetyl resorcinol in glycerin solution.

238. Productiou of saccharin and chloramine T from toluene.

B. H. Shivjiani *and* R. C. Shah, Bombay.

An exhaustive study has been made of the various stages involvep in the production of saccharine and chloramine T from toluene with a view to arrive at the best conditions for their economic preparation. Some modifications and improvements of the existing processes have also been worked out.

239. Kostanecki-Robinson reaction on orcpropiophenone.

P. L. Trivedi, S. M. Sethna *and* R. C. Shah, Bombay.

In continuation of previous work (Sethna and Shah, *J. Ind. Chem. Soc.*, 1940, **17**, 239, 487), orcpropiophenone, prepared from orcinol and propionitride has been acytylated with sodium acetate and acetic anhydrilo. The product -7 acetoxy-2 : 3 : 5 trimethyl chromone has been converted into 7-hydroxy-2 : 3 : 5 trimethyl chromone. The constitution of the hydroxy chromone has been established by its unambiguous synthesis, through the condensation of oracetophenone dimethyl ether with ethyl acetate, methylation of the resulting B-diketone and subsequent cyclization of the c-methylated compound to the methoxy chromone which is demethylated.

240. Composition of the fatty acids of the oil from *Azadirachta indica.* (Margosa or Neem oil).

C. J. Dasa Rao, Waltair.

In view of the large use of neem oil for medicinal purposes particularly in connection with skin diseases the composition of the fatty acids becomes important. The recent work of Khuda and workers suggests the possibility for the existence of new components. A genuine sample of neem oil has been therefore carefully purified and analyzed and the results are reported.

241. Nitration of Thymol and its derivatives.

J. R. Palande *and* V. A. Patwardhan, Poona.

It is known for some time now that in the nitration of thymol in the presence of sulphuric acid, the isopropyl group is replaced by the nitro group, and therefore nitro-*m*-cresols are the main products of the reaction. By using acetic acid however, as the solvent in place of sulphuric acid, nitro-thymols have been obtained. In the nitration of thymyl methyl ether also in sulphuric acid, cresol compounds are formed, and in acetic acid, 4-nitro-thymyl methyl ether, b.p. 172°/18 mm. has been obtained. This is reduced to the amino-compound, the acetyl derivative of which melts at 140°C. When acetic acid and acetic anhydride are used as solvents in the nitration process, ortho-substituted derivatives are generally formed in greater proportion. The nitration of thymyl methyl ether in acetic anhydride has however mainly yielded the 4-nitro-thymyl methyl ether. The nitration of thymyl acetate also in acetic anhydride has given 4-nitro-thymyl acetate, b.p. 176-177°/4-5 mm., from which by hydrolysis, 4-nitro-thymol, m.p. 140°C has been obtained.

242. Fixed oil from the seeds of *Jatropha curcas.*

M. T. Bapat *and* V. A. Patwardhan, Poona.

Jatropha curcas (N.O. Euphorbiaceae), physic nut or Mogali erand is an evergreen plant, common in waste places and cultivated on the hedges. It bears round yellow fruits, from which black seeds are available. The kernels of the seeds resemble peanuts in colour, size and appearance.

The seeds are also known as purging nuts, the oil being rather drastic in its action in comparison with castor oil. It is stated that the oil, leaves and stems of the plant have several medicinal uses. The kernels of the seeds on extraction with ether yielded about 56·5% of an almost colourless oil, which showed the following characteristics: Saponification Value, 195·2, Iodine V. 104·3 (Winkler), Acid V. 6·5, Acetyl V. 10·5, Unsaponifiable matter 1·8%. The mixed fatty acids obtained from the oil gave 17·7% of saturated fatty acids by means of the Twitchell's process. The mixed saturated fatty acids melting at about 52°-53°C. had an equivalent weight of about 270. The liquid acids,—Iodine V. 119, showed on bromination that linolenic acid was absent. The examination of the fatty acids in detail is in progress.

243. Preliminary studies on uncalcined kyanite-clay mixtures.

T. W. TALWALKAR *and* A. K. SINHA, Jamshedpur.

Several workers have already reported on the volume changes and other properties of mixtures of uncalcined kyanite with clays and bauxite or diaspore, etc. and it has been shown that some of these mixtures have little or no change from the unfired volume to the fired volume. Presumably the expansion of kyanite and the contraction of the other materials in these mixtures have been well-balanced. Some further data along the same lines is presented here using local kyanite and clays. Two different types of mixtures can be developed as follows:—

(*a*) Mixtures in which the fired volume at a given temperature is the same as the unfired volume but in which there may be some abrupt changes of volume in the intermediate stages.

(*b*) Mixtures in which there is a small amount of contraction from unfired to fired state but in which there is little abrupt change at any intermediate stage.

The major expansion of kyanite in this work took place at or below 1300°C and it was seen that lower grade type of fire clays make better mixtures than high grade clays.

Section V, Geography and Geodesy.

17. Battle of the Kangdali.

SWAMI PRANAVĀNANDA.

(of the Holy Kailas and Manasarovar).

Away up in the Himalayas, 100 miles north of Almora, a section of the Bhotias celebrate once every twelve years a queer festival which they call 'Kangdalika-ladai' or the Battle of the Kangdali. Sharpened weapons are wielded with right goodwill, heads, unceremoniously lopped off by warriors urged on to victory by frenzied drumming and cheering crowds, are gathered up in silken cloths by fond wives, daughters and sweethearts, but still the Bhotias suffer no casualties in their ranks.

For the Kangdali is merely a psychic enemy—a four-foot high shrub which, the Bhotias believe, must not be allowed to flower freely lest evil befall their womenfolk.

Usually the people belonging to each village collect together, and all irrespective of age, sex, or status, participate in this 'battle', which lasts for about a week. They make the necessary preparations such as white-washing and plastering their houses, frying pancakes, brewing barley liquor, and invoking their village deity with cries of 'Parameshwara' during the first three days.

The Battle.

The actual 'ladai' takes place on the fourth day. Men in long white gowns and *pagris*, and women in colourful silks, woollens and heavy necklaces of silver coins, assemble in front of a prominent villager's house and after a drink start in procession, headed by drums and cymbals. They conduct the march in single file, the men with swords and shields or *lathis* and bunches of green leaves in their hands, being followed by the women holding long wooden lease-rods called 'rel' in one hand and coloured silk cloths in the other.

Dancing and swinging their swords and 'rel' in graceful sweeps, they advance until they reach a mountain spur and halt. Shots are fired, the drumming becomes frenzied, then off down the mountain slopes spotted with Kangdali in bud and blossom rush two men, shouting war cries and brandishing their swords. The women immediately follow suit.

After chopping off the flowers of the ominous shrub, they turn back, bringing with them the trophies amidst deafening shouts of triumph. They then dance for a while and return to their village in procession.

It is evening by now and they gather in a courtyard and begin the popular circle-dance which invariably lasts till midnight and not infrequently the whole night. During this dance, they all form a circle and move counter-clockwise, singing love-songs in a monotonous yet impressive mountain tune which certainly appears to befit those lofty surroundings. Men and women mix freely without any sign of shyness. Young men and maids from far off places go here as if to a fair, and many a match is made. This care-free feasting and revelry lasts for two or three days more.

Besides this twelve-yearly 'ladai' they have an annual 'Tyohar' or festival, held during 'Dassera' which closely resembles the Kangdali festival, except that the 'Kangdalis' are not again attacked.

18. New light of the sources of the four great rivers of the Holy Kailas and Manasarovar.

SWAMI PRANAVĀNANDA

(of the Holy Kailas and Manasarovar).

In this paper the findings of the great Himalayan explorer Dr. Sven Hedin regarding the sources of the Brahmaputra, the Sutlej, and the Indus have been seriously questioned and challenged ...... If the river in question happens to have more than one headstream, which of them is to be considered the main river? Is it decided by the quantity of water that it brings down or by the length of the particular headstream? Or is the source located from the traditions of the local people? If all the three conditions are not fulfilled, as they are often not, which of them should be given the greatest weight? and why? ..... There had long been a controversy over the sources of these rivers till matters were taken to have been set at rest by Sven Hedin's findings in 1907-8. By giving preference to the quantity of water in the case of the river Brahmaputra, tradition in the case of the Indus, and far-fetched tradition and length in the case of the Sutlej, Sven Hedin mercilessly sacrificed all consistent, reasonable, and uniform procedure, since he had to labour under the restrictions of the Tibetan officers and of time, at the time of fixing the sources of these river, while at the same time he claims himself to be the first 'white man' and 'European' discoverer of the sources of these three rivers .... At last it was in the year 1937 that I succeeded in. discovering the sources of these Four Great rivers—the Brahmaputra, the Sutlej, the Indus, and the Karnali—from all points of view, namely, tradition, quantity of water, length, and glaciers, after actually visiting all the places.

According to Tibetan traditions the source of the Sutlej (Langchhen Khambab) is in the springs near Dulchu gompa; that of the Indus (Singi Khambab) is in the Singi Khambab springs; that of the Brahmaputra (Tamchok Khambab) is in the Chemayungdung glaciers; and that of the Karnali (Mapcha Khambab) is in the spring Mapcha Chungo. In this case the genetic sources of all the rivers excepting that of the Indus are all glacial. Should the quantity of water be taken into account the source of the Sutlej is at the head of the Darma yankti near Darma Pass; the source of the Indus is at the head of the Lungdhep Chhu near Topchhen la; the source of the Brahmaputra is in the Kubi glaciers; and that of the Karnali is near the Lampiya pass. In this case the sources of all the four rivers are glacial, but the traditional sources of all excepting that of the Karnali are dislocated. Should length be the test, the source of the Sutlej would be in the Kanglung Kargri at the head of the Tag, or at the head of the southern tributary of the Tag, or that of Samo tsangpo; the source of the Indus would be in Topchhen la, that of the Brahmaputra in the Chemayungdung glaciers; and that of the Karnali near Lampiya pass. When length is taken as criterion, the sources of all the rivers are at the traditional places except that of the Indus; but the sources are all glacial. But Sven Hedin's source of the Sutlej in the Kanglung Kangri, of the Indus in the Singi Khambab springs, and that of the Brahmaputra in the Kubi glaciers would not satisfy any one of the above three criteria—tradition, volume, or length—in its entirety and as such he cannot claim to be the first discover of the sources of these rivers.

19. Ganges-Sutlej confusion.

SWAMI PRANAVĀNANDA

(of the Holy Kailas and Manasarovar).

For several generations there had been a hopeless confusion of the rivers Ganges and Sutlej which is mainly two-fold; some were under the wrong notion that the Ganges and Sutlej took their rise from Manasarovar and Rakshas Tal, while some others confounded the Ganges with the Sutlej, or made one the tributary of the other. The ancient Chinese geographers Jesuit fathers, Isbrants Ides (1704 A.D.), Desideri (1715), Father Gaubil (1729), D'Anville (1735), Father Joseph Tiffenthaler (1765 ?), Pt. Purangir (1773), Major Rennell (1782), Captain F. Wilford (1800), Webber (1886), Ekai Kawaguchi (1900), and a host of others, all made a huge confusion of the two rivers as mentioned above. Even to-day many orthodox and religious minded Hindus as well as cultured Indians confound the Ganga Chhu (the outlet of Manasarovar into Rakshas Tal) with the river Ganges, though actually the distance between the real source of the Ganges at Gomukh and the Lake Manasarovar is over 140 miles as the crow flies.

It is the word 'Ganga Chhu' which has misled the Indians and the early explorers and writers to believe that the Ganges had its source in the Manasarovar; and it is the Indian equivalent 'Ganga' for the Langchhen Khambab (Sutlej), in the Kangri Karchhak (Tibetan Kailas Purana) that has misled Tibetans to believe that the Ganga or Ganges at Hardwar is the same as the 'Ganga Chhu' and consequently the Sutlej.

20. Confusion of Tso Kapala with Thuki Zingboo or Gourikund.

SWAMI PRANAVĀNANDA

(of the Holy Kailas and Manosarovar).

The lake Thuki Zingboo or Gaurikund is situated due east of Mount Kailas, at an altitude of 18,200 ft. above the sea-level. Situated at the southern foot of Kailas peak, at a distance of 6 miles from Tarchhen (wherefrom the circumambulation of the Kailas mountain begins) are two very small lakelets called Rukta and Durche, of black and white waters respectively. They are jointly called Tso Kapala. Dr. Sven Hedin wrongly placed Tso Kapala in the Gourikund, since he saw only the Gourikund but not the other. I am the first non-Tibetan who had ever visited Serdung Chuksum and Tso Kapala.

Section VI, Botany.

33. A new genus of Saprolegniaceae.

H. CHAUDHURI, Lahore.

Hamidia gen. nov. has been isolated, grown in culture, and described and a new species *Hamidia indica* sp. nov. established. The Latin diagnosis in both cases has been given.

34. Some new water moulds from the Punjab.

ABDUL HAMID, Lahore.

Two species of Achlya, viz., *Achlya oblongata* and *A. androcomposita*, nov. spp. and one species of *Pythiogeton*, viz., *P. sterilis* nov. sp. have been described.

Section VII, Zoology.

49. An indigenous substitute for Canada Balsam.

B. THIRUMALACHAR, Tumkur (Mysore).

The author recommends the use of the resin of the widely distributed Dhupa tree (*Vateria indica*) of Indian forests as an indigenous substitute for Canada Balsam which is at present scarcely available owing to the war.

The methods of preparing the resin as a mounting medium are described. The high solubility of the resin in xylol, ether, chloroform and petrol, the sticking properties of the prepared product, the refractive index (1·5), the cheapness and easy availability of the resin are all in favour of its being used as an efficient substitute for Canada Balsam.

Section VIII, Entomology.

36. Some important features of the Rhynchota fauna of Afghanistan.

HEM SINGH PRUTHI, New Delhi.

Very little is known about the insect fauna of Afghanistan, much less about the order Rhynchota. Only about a dozen species of Rhynchota which were collected by the German Hindukush Expedition are so far known.

The material collected by Dr. Taskhir Ahmad, who went to Afghanistan in June 1939 as a member of the Indian Agricultural Delegation, includes about sixteen species of Aphididae, of which five are new species and thirty species of other Rhynchota.

With regard to the distribution of Rhynchota the country can be divided into two natural regions:

Low altitudes:—This region includes Afghan-Turkistan and the South-western Afghanistan. Very few aphid species were collected in this region, probably due to hot weather during the period of collection. *Lygus pratensis* (Linn.) (Capsidae) on berseem, maize and cotton, *Stephanitis* *pyri* (Febr.) on apple and *Monosteria unicostata* (Tingididae) were very common in July, the last two causing severe damage. The former is a serious pest of pear and apple in Europe and America but is fortunately absent from India. The other sucking insects were Pentatomidae, viz. *Eurydema festivum* var. *chloroticum* Hov., *E. festiom* var. *pictum* (H.—Schäffer) and *E. festivum* var. *decoratum* (H.—Schäffer) on carrot and apricot.

High altitudes:—The Kabul plateau and the Hazarajat—The most common insects in this region were the aphids. A new species of *Hyalopterus* was found causing serious leaf-curling to peach, plum, apricot and bamboo. Three gall-producing aphids, all new to science, were fairly common on poplar. There were two species on walnut, *Chromaphis juglandicola* (Kalt.) a well known European and American aphid and *Callipterus juglandicola* (Frisch.). The species common to India are *Aphis laburni* Kalt., and *Pterochlorus saligna* Gnelin on willow, *Macrosiphum pisi* Kalt. on berseem and bean and *M. rosae* (Linn.) on rose.

37. Biology of *Laphygma exigua* (Hübner).

HEM SINGH PRUTHI, New Delhi.

Laphygma exigua is almost a cosmopolitan and polyphagus insect, occurring throughout India and other parts of the world. It is a pest of major importance and is serious usually during autumn, winter and early spring. Its host-plants at Delhi are more than 30, both cultivated and wild. Cultivated hosts include lentil, lucerne, gram, peas, linseed, chillies, etc., while *Tribulus terrestris*, *Ipomoea pestigridis*, etc., are wild.

Female lays eggs in clusters of 100-500 each, felted over with fine woolly threads of dirty white colour. They hatch in 3–10 days. The caterpillar moults 5 or 6 times, during which period it presents great variation in colour irrespective of the plant it feeds on. The larval period occupies 15–20 days after which the caterpillar pupates 2″–4″ below the surface of the soil in a small earthen chamber. Pupal period lasts 1–4 weeks.

Laphygma exigua has 9-10 generations in a year at Delhi, breeding rapidly during autumn, winter and early spring, completing one cycle in about 3 weeks, while during hot weather it breeds slowly, completing one generation in a month or more.

The larva is parasitised by *Apanteles paludicolae* Cam. The percentage of parasitization in the field is about 10 during active period of its breeding.

38. The Biology of the Weevils, *Sitophilus oryzae* and *Sitophilus granarius*, with special reference to the effects of temperature and humidity on the rate of their development.

QADIRUDDIN KHAN, Hyderabad.

The biology of the Weevils, *Sitophilus oryzae* and *Sitophilus granarius*, not being previously described in detail, has now been closely studied, and the following results have been obtained:—

(1) The preoviposition period differs markedly in both the species at every temperature and humidity combination.

(2) The incubation period of the eggs behaves exactly like the preoviposition period in response to temperature and humidity.

(3) The first three larval instar stages in both the species are of equal duration, but the fourth instar is longer in duration than each of the previous instars, especially at high temperatures. The larval periods of *S. oryzae* at low temperatures are slightly longer than those of *S. granarius*.

(4) The pupal period is more affected by the relative humidity than by the temperature.

(5) At all temperatures and relative humidities the total developmental period of *S. oryzae* is shorter than that of *S. granarius*.

Section IX, Anthropology.

14. Premarital Puberty Rites of Girls in Western Maharashtra.

(MISS) DURGA N. BHAGVAT, Bombay.

Anthropological information regarding puberty rites of girls before marriage is scanty. In the Anthropological surveys of Northern India such references are not found. In Southern India, the rites are observed by some castes and tribes.

Ceremonial defloration of a girl at the first menstruation is suggested by certain rites and songs of the Marathas and Kunbis in the Konkan. The rites are symbolical of ceremonial defloration of the girl by her maternal uncle and the songs allegorically describe the advent of menstruation and the prospect of fertility.

Section X, Medical and Veterinary Research.

24. On the distribution of phosphorus in human, cow, buffalo, sheep and goat milks.

K. P. BASU *and* K. MUKHERJEE, Dacca.

The distribution of phosphorus compounds in milk of different animals, cow, goat, sheep and buffalo and also of human beings has been investigated.

Total phosphorus in cow, goat and sheep milks per 100 c.c. was found to be nearly the same (100 mg.). Buffalo milk contains about 125 mg. phosphorus while human milk contains only 30 mg. phosphorus per 100 c.c. The organic phosphorus was found to be labile in nature and gave phosphate in presence of ammonium molybdate-sulphuric acid mixture. Total acid soluble phosphorus was found to be equal to the sum of inorganic phosphorus and organic ester phosphorus (as creatine phosphate) within the range of experimental error. Hexose diphosphate phosphorus was only found in very minute quantities in cow's milk.

25. Musk and Musk-deer.

SWAMI PRANAVĀNANDA

(of the Holy Kailas and Manasarovar).

Musk-deer is chiefly an inhabitant of the Himalayas, Tibet, and Central Asia. It belongs to the deer family but smaller in size. That gland of the animal which contains musk is commonly called 'musk pouch' or 'musk pod'. The writers of Ayurvedic works believed musk to be either the content of umbilicus or sperm. So, in Sanskrit it is called '*mriga-nabhi*', '*mriga-mada*', or '*kasturi*'. Neither the scientific works, nor the Encyclopaedias, not even the Zoologist could give us a more accurate or first hand information regarding the origin of musk, for they vaguely say that, 'musk is the secretion of musk-deer', 'musk is the dried secretion from the preputial follicles of the male musk-deer', 'musk is obtained from the scrotum', 'a skin-pit in mammals producing a secretion with a musky odour, especially in the male musk-deer', 'musk-deer secretes in its gland a substance with a strong odour', 'musk produces the perfume called musk', and so on. By varied researches during the last several years, by visiting the abodes of the musk-deer, by examining several musk pods from different parts of the Himalayas and Tibet, and finally by disecting a freshly killed deer, I came to the definite conclusion that the musk pod is the prostate gland of the male musk-deer and that musk is the secretion of the prostate gland.

Besides my actual findings, even from a logical point of view, musk cannot be the product of the umbilical knot. Both the male and the female have umbilicus; then how can it be, that the umbilical knot of the male alone contains musk, but not the female? Umbilicus has neither any secretion nor does that secretion go to the urethra; when such is the case why should the urine of the musk-deer, and that too of the male alone smell of musk. So musk must be the secretion of such a gland which is, peculiar to the male and not present in the female and the secretion of which enters the urethra. Prostate gland satisfies these conditions. Musk pod being taken from near the male organ, can neither have its origin in the testis nor can it be its product sperm. Hence musk-pod must be the prostate gland and prostate gland only and nothing else. The umbilicus of the animal is hidden under thick hair and is so very near the male organ (at the root of which is the prostate), that the latter is confounded with the former, by the layman and his informant, the *shikari* (hunter); and hence the wrong notion that musk is the product of *nabhi* or umbilicus. Synthetic musk was first manufactured in the year 1888, which has an odour, much akin to musk and which is used only for perfuming purposes; but it does not possess the medicinal properties of real musk. The musk contained in a musk-pod varies from half a tola to two and a half tolas in weight. Musk is dark-purplish or brownish in colour; and the one in grannular form, got from the aged deer is considered the best. The price of musk per tola ranges anything from Rs.13, which a *shikari* gets, to as much as Rs.75, which a consumer has to pay in the plains. It is considered that the Tibetan deer yields the finest musk, though there is difference of opinion. As soon as the animal is killed, the prostate gland is removed along with the male organ and the skin around it and the mouth of the pod is tightly tied. The *shikaris* of Darma keep the male organ intact with the musk-pod, whereas others remove it and burn the spot slightly to cover up the hole. Very often dried up blood and flesh are mixed in real musk to adulterate it. Some Kabulis, Garhwalis and Khampas prepare spurious musk-pods beyond detection.

Musk produces heat in the body, stimulates the heart, and raises blood pressure in depressed conditions of the system. It is one of the best aphrodisiac drugs and a good rejuvenator—*Vajikaran*. It is used in colds, for newly delivered women, and in most of the Ayurvedic tonics, to enhance their action. Injections of 'musk in ether' are manufactured for quicker results. The scent of musk is most penetrating and more persistent than any other known substance and hence its importance for perfuming purposes. Arabs first took it to the West in 1189 A.D. The English word musk is derived from the Arabic '*misk*' and the Persian word '*mushk*'. Tibet exports maximum quantities of musk to other countries. The canine teeth of the musk-deer are used as jewellery by Bhotia women; and the pith-like hair is scraped out of the hide and is used for stuffing cushions.

Section XI, Agriculture.

61. Studies on flood resistance in *Aman* (deep water winter paddy).

P. M. GANGULI *and* J. L. SEN, Habiganj (Assam).

Aman plants of different ages were subjected to different depths and durations of submergence in factorial experiments conducted in the Deep Water Paddy Research Station, Habiganj (Assam). The study of the association between the height of the plants before their submergence and their growth rate below water and also the comparison of the survival percentages and the yields noticed for different ages under the conditions of different depths and durations of submergence indicate that the seedlings of six weeks and above are least affected by submergence. Thus, if there be an interval of six weeks between the *Aman*-sowing and the advent of flood, then the seedlings can rise above water even if they be submerged.

Section XII, Physiology.

41. Effect of nicotine on respiration.

S. A. RAHMAN *and* R. N. ABHYANKAR, Hyderabad-Deccan.

The action of nicotine on respiration was investigated on rabbits and dogs. In the rabbit, intravenous injection of nicotine gave rise to apnoea followed by hyperpnoea in ten out of eleven cases. The apnoea was in the position of full inspiration. Similar result was obtained in the dog where the apnoea was in the position of expiration.

The carotid sinus in the dog seems to be more susceptible to the action of nicotine in producing hyperpnoea than in the rabbit.

There is a suggestion that nicotine may act on the vagal afferents in the lungs, the impulses from which may contribute to the production of apnoea.

42. Amino-acids in blood formation. I. Tryptophane.

(MISS) K. M. YESHODA, K. RAMAKRISHNAN NAIR *and* M. DAMODARAN, Madras.

Three groups of rats weighing between 50 and 60 g. were maintained on diets the amino-acid content of which was varied by giving to the animals of group (i) whole casein, to group (ii) hydrolyzed casein in which tryptophane was destroyed by acid and to group (iii) hydrolyzed casein supplemented with 20 mg. tryptophane per rat per day. The average weekly increases in the R.B.C. of animals of group (i) and (iii) were practically identical and slightly but definitely higher than that of group (ii) on the tryptophane free diet. The significance of the results is being further investigated. Rats of the second group ceased gaining in weight after the first four weeks while the animals in the other two groups maintained a steady increase in weight throughout the experimental period of two months.

43. Transamination.

M. DAMODARAN, (MISS) P. DEVI *and* S. MANDESWARA SASTRI, Madras.

Transamination or the transfer of amino-groups from the dicarboxylic amino-acids to keto-acids corresponding to other amino-acids and *vice versa* (equation below):—

$$\begin{array}{l} COOH \\ | \\ CH\,(NH_2) \\ | \\ R \\ | \\ COOH \end{array} + \begin{array}{l} COOH \\ | \\ CO \\ | \\ R_1 \end{array} \rightleftharpoons \begin{array}{l} COOH \\ | \\ CO \\ | \\ R \\ | \\ COOH \end{array} + \begin{array}{l} COOH \\ | \\ CH\,(NH_2) \\ | \\ R_1 \end{array} .$$

first discovered by Braunstein and Kritzman in rabbit and pigeon muscle has been claimed by these authors to be applicable to all amino-acids and to both the vegetable and animal kingdoms. The present experiments carried out with tissue slices suggest however that transamination is limited to alanine among the mono-amino acids. Evidence has been found for the existence of a similar transaminating system, as between glutamic or aspartic acid and pyruvic acid, in the seedlings of various legumes.

2. ERRATA AND ADDENDA.

Proceedings of the Twenty-ninth Indian Science Congress

BARODA, 1942

PART III—ABSTRACTS

(1) *Section of Chemistry.*

[Paper No. 92 on page 73 of Part III of the Proceedings of the 29th Session.]

In line 6—

Read :

$56{\cdot}0 \times 10^{-3}$ N and $64{\cdot}0 \times 10^{-3}$ N.

Instead of :

$56{\cdot}0 \times 10^{-5}$ N and $64{\cdot}0 \times 10^{-5}$ N.

In line 7—

Read :

*p*K.

Instead of :

*p*H.

(2) *Section of Geology.*

[Paper No. 9 on page 114 of Part III of the Proceedings of the 29th Session.]

In line 10—

Add :

'The evidence from Ceylon suggests that the formation of a Siwalik fossil first undergoes a swamp phase than a dry one, the result of Pleistocene upheaval.'

After the words 'Although less advanced' and before the words 'In Ceylon'.

At the end of the last line on page 114—

Add :

'and an anthracothere premolar',

between the words 'in one locality' in page 114 *and 'all combine to' in page* 115.

After the end of the 2nd line on page 115—

Add:

'The Ratnapura fossil horizon rarely exceeds three feet in thickness, but it contains in association fossils occurring elsewhere in beds many thousands of feet thick.'

(3) *Section of Zoology.*

[Paper No. 3 on page 148 of Part III of the Proceedings of the 29th Session.]

In line 3 (title of the paper)—

Read:

Specimens.

Instead of:

Species.

In last two lines of the paper—

Read:

'attach themselves to encrusting masses which are seen to roll again into spherical bodies'

Instead of

'attach to the substratum by coarse reticula and give rise to small encursting sponges.'

Sub-heading on page 148.

Read:

'Coelenterata'.

Instead of:

'Coelentarata'.

[Paper No. 30 on page 157 of Part III of the Proceedings of the 29th Session.]

Read the title of the paper as follows:—

'Observations on the protective egg envelopes of some oviparous and viviparous Elasmobranch fishes of the Madras Coast.'

Instead of:

'Observations on the protective envelope of some viviparous elasmobranch fishes of the Madras Coast.'

3. DISCUSSIONS

I. THE USE OF FACTORIAL AND INCOMPLETE BLOCK DESIGNS IN AGRICULTURE.

(Sections of Mathematics and Statistics, and Agriculture, in co-operation with the Indian Statistical Conference.)

SIR T. VIJAYARAGHAVACHARYA, Udaipur, presided.

1. DR. V. G. PANSE, Indore.

Application of statistical methods to agricultural research has resulted in the rationalization of various aspects of experimental work. Introduction of factorial designs has been a step in the same direction. With their adoption, the objective of the experiment is more clearly defined and arbitrary treatment combinations selected mainly on personal opinions as to their utility and effectiveness are replaced by a comprehensive set of treatments entirely determined by the object of the trial. To counteract the loss of efficiency due to an increase in the size of block resulting from a large number of plots, the device of 'confounding' is proposed whereby it is possible to include in one block only a part of the total number of treatments to be tested.

Various incomplete block or lattice designs have been recently developed to supply the plant breeder's need of suitable designs for testing a large number of varieties. Here also, block size is reduced with a corresponding increase in efficiency by including in one block only a fraction of the total number of varieties under trial. This is done by making use of the principle of confounding certain pseudo-factors which are components of the varietal comparisons.

On the mathematical side these designs have opened a new and interesting field and there is no doubt that many more patterns will still be evolved. The agricultural investigation of the problem is unfortunately lagging behind and information on the limitations, possibilities and other special features of these designs from the point of view of the agricultural experimenter is urgently needed. The gain in accuracy expected from the adoption of these designs is offset by certain disadvantages, such as, the partial or complete loss of information of certain treatment effects in agronomic trials and a reduced theoretical efficiency of varietal comparisons in incomplete block trials, the need of greater care in field work and the increased intricacy of the arithmetical computations in the analysis of results. An experimenter would not therefore wish to sacrifice the simplicity and flexibility of ordinary randomized blocks by adopting confounding, unless there is a possibility that the desired standard of accuracy cannot be attained by employing a simple layout.

An investigation for comparing the efficiency of ordinary randomized blocks with confounded and incomplete block designs was recently carried out at Indore with the help of a uniformity trial on cotton. These results are in press and will appear in the *Indian Journal of Agricultural Science*. Plots of four sizes, 1/50, 1/100, 1/200 and 1/500 acre, were studied. Some of the results are briefly given here. The gain in efficiency due to confounding increased when a larger number of plots was included in each replication and smaller sizes of plots were adopted. With only 16 plots per replicate, confounding by subdivision into blocks of four plots was under 40% more efficient than ordinary randomized blocks for all plot sizes; but with 64 plots of 1/200 or 1/500 acre size to a replicate, a subdivision into blocks of a quarter or smaller size increased the gain two-fold or more. For varietal trials with 16 varieties an incomplete block arrangement in a square lattice was actually found to be less efficient than ordinary randomized blocks for plots of all sizes; but a similar design for 64 varieties proved definitely more profitable with plots of 1/200 and 1/500 acre size. It appears that incomplete block designs would be really useful when the number of varieties to be tested is 50 or 60 or more. With a smaller number, the employment of these designs is of doubtful value. Confounding in agronomic trials would be definitely more effective with a smaller number of treatments; but the gain in efficiency when there are only 16 treatments may not always be considered worthwhile. These results are not quoted here for making any general recommendations, but merely as an example of the kind of information it is desirable to collect in order to enable the experimenter to make the best use of various available designs.

2. MR. R. C. BOSE, Calcutta.

In a varietal trial or in a factorial experiment when the number of treatments to be tested is large, the ordinary randomized block design becomes inefficient. This is due to the fact that a large block size brings in its train increased residual errors per plot, so that differences between treatments which are to be tested against these residual errors become obscured. In order to avoid this difficulty various methods of reducing the block size have been proposed, for example, confounding in the case of factorial experiments, balanced incomplete block designs and quasi-factorial or lattice designs in the case of large varietal trials. Recently at the Statistical Laboratory, Calcutta, certain new designs called partially balanced incomplete block designs have been worked out which include as a special case both the balanced incomplete block designs and the lattice designs. In adopting any new design some information is always lost on some higher order interaction in the case of the factorial designs and for all treatments in the case of incomplete block and quasi-factorial designs, provided that there is no reduction in the residual error per plot due to the reduction of the block size. As a matter of fact when the number of treatments is large, the loss of information will generally be offset by the reduction in the residual error per plot so that in factorial experiments it may happen that those interactions on which information has been partially lost may be estimated with greater precision by the adoption of confounded designs. Similarly in varietal trials also a greater net precision may result by the adoption of the newer designs. The question that faces the agricultural experimenter is which design to utilize under particular circumstances. In replacing the randomized block design by any other design he must be able to make sure that the loss of information is offset by the reduction in residual error per plot. What Dr. Panse has said shows that in the case of 16 varieties the replacement of the randomized block design by the 4×4 lattice design is not justified. The efficiency factor for the 4×4 lattice design is rather low being 5/8. The reduction in block size from 16 to 4 does not lower the residual error sufficiently to offset this low efficiency factor. I wonder if the balanced incomplete block design in which $v = b = 16, r = k = 6, \lambda = 2$ had been used, for which the efficiency factor is 8/9, what the result would have been. Here the loss of information is only 1/9 and it is possible that it would have been more than offset by the reduction in the residual error, due to the change of block size from 16 to 6. The partially balanced designs investigated at Calcutta afford the agriculturists a large number of designs of the same class as the lattice designs. By the use of these designs the agriculturist can select a block size that will suit his particular requirements. Here we have v varieties, b blocks of k plots each, each variety being replicated r times. With respect to any variety, the remaining $v-1$ fall into two groups of n_1 and n_2 such that the varieties of the first group occur λ_1 times with the given variety and the varieties of the second group occur λ_2 times with the given variety. Certain other conditions must also be satisfied, in order that the analysis may be easy. Various geometrical and algebraical methods have been used to construct these designs but a lot of work still remains to be done. I strongly hope that the wide choice which these designs present to the agriculturist, will in most cases enable him to select one which is appropriate to the problem with which he is dealing.

3. Mr. K. Kishen, Cawnpore.

One of the important tasks of the modern agricultural experimenter is the evolution of new varieties for a given crop and conduct trials with them so as to select the best ones from among them, as judged from both the quantitative as well as qualitative point of view. As, further, soil in any place is likely to be deficient or efficient in one or the other of the standard fertilizers like nitrogen, superphosphate or potash, and varieties respond differently to them, an ideal experiment fully serving his purpose would be one combining varietal and manurial trials. Such an experiment, I say, would be an ideal one in the circumstances and repetition of it for a couple of years to take account of seasonal variation and at several places to take account of variation in soil types from place to place is likely to yield conclusions having a degree of reliability and general applicability not achievable otherwise.

Let us now consider the difficulties attending the actual conduct of such an ideal experiment. These are partly experimental and partly statistical. Among experimental difficulties may be mentioned inadequacy of seed material, available land, etc., at the disposal of the experimenter. The seed material is invariably insufficient in the beginning; and even if the requisite land were available, it will not be possible to conduct full-scale field trials right in the beginning.

However, statistical difficulties apart, from the practical point of view such large-scale trials are not possible to conduct right from the beginning. The only course for the experimenter in the circumstances is to conduct a single-factor experiment with varieties only, and then his plots must be very small in size. On account of the large number of varieties the need for the reduction of the size even here is evident. If the number of varieties is factorizable into $p \times q$, we may adopt a two-dimensional rectangular lattice design in two groups of sets or partially balanced equal or unequal block designs, some aspects of which have recently been discussed in *Sankhya*. In other cases, symmetrical and partially balanced incomplete block designs with equal or unequal block sizes are available. Of course all the statistical difficulties in this connexion have not been overcome and much work requires to be done on the construction of these new designs. The theoretical efficiency of the various designs have been worked out on the assumption that there is no reduction in the error variance per plot due to the reduction of size per plot. But this does not often happen in actual practice, the reduction in error variance being in many cases marked. We have heard with great interest the conclusions arrived at by Dr. Panse in regard to the actual efficiency of the two-dimensional square lattice design as compared with the ordinary randomized block. His work amounts to a condemnation of these designs when the number of varieties is less than 50. This is not surprising as two-dimensional lattice designs are particularly inefficient. Dr. Panse has not, however, considered the actual efficiency of the other designs, namely, symmetrical and partially balanced incomplete block designs in equal or unequal blocks in the case of cotton crop. Such work on uniformity trials not only for cotton but other crops is likely to be of value to the statistician in making up his mind as to the most appropriate design in any given case.

When, after conducting a suitable test with a large number of varieties, the experimenter has been able to make a small representative selection of the best varieties from among them, he can arrange a factorial design with manure, irrigation, cultural operation, etc., as the other sets of factors, and from the resulting factorial design he will finally be able to select the best variety and the optimum level of manuring, irrigation, etc., for it.

4. MR. R. S. KOSHAL, Bombay.

The introduction of factorial and incomplete designs has opened new fields of mathematical research, and in this connection must be mentioned the important contribution by R. C. Bose, on the construction of Balanced Incomplete Block Designs.

On the applied side, very few factorial experiments have been designed and studied with reference to quality of cotton. A complex experiment on Cambodia cotton involving three sowing dates, two irrigations, two levels of basal dressing, and three levels of top dressing was studied and described with reference to fibre maturity by A. N. Gulati (*J. Agri. Science*, Vol. XI, 1941). Another complex experiment, in which two varieties 4F98 and Sind Sudhar, five manurial treatments, and three types of irrigations are included, is being studied by Mr. S. M. Navaz at Sakrand. In 1939-40, two manurial trials on C520 and Perso American, were conducted at Raya and Belatal, in the United Provinces. The experiment at both places was arranged in four randomized blocks, each block having twelve treatments, each treatment with two sub-plots for the two varieties of cotton. The twelve treatments consisted of all combinations of four levels of sulphate of ammonia, nothing (n_0), 15 lbs. of N per acre (n_1), 30 lbs. of N per acre (n_2) and 45 lbs. of N per acre (n_3); and three levels of superphosphate, nothing (p_0), 15 lbs. of P_2O_5 per acre (p_1) and 30 lbs. P_2O_5 per acre (p_2). The yield data for 96 plots was thus available from each place, but the produce of the four replications was unfortunately mixed for the study of quality. This experiment is being studied by Mr. S. Samson at Cawnpore. The three fibre-properties examined were: fibre-length, fibre-weight per unit length and fibre-maturity. The analysis of fibre-weight results indicated that the main effects, comprising three degrees of freedom for units of phosphate, and the six degrees of freedom for their interaction were all non-significant. But, when these were further sub-divided into single degrees of freedom, one sub-division of the interaction, corresponding to the interaction of linear response of nitrogen (N') and the curvature (P'') for phosphate was found to be significant.

In order to study further the optimal levels of fertilizers in relation to quality of cotton, it is proposed that the factorial experiments at Raya and Belatal, may again be conducted next year. For this purpose, three levels of N, P and K may be included, giving in all 27 treatments. Two replications would be sufficient and in order to attain greater efficiency, several types of confounded designs can be adopted, but the simplest would be to allot 27 treatments within each replication to 3 blocks of 9 plots each, so that the four degrees of freedom out of eight for three-factor interactions are partially confounded with blocks. With two varieties, 108 samples would be available from either place, and in view of the laborious nature of tests on quality, the material would be regarded as quite sufficient.

5. MR. S. S. IYER, Delhi.

Mr. S. S. Iyer dealt with some of the practical difficulties which the experimenter has to face in laying down many of these incomplete block (and other confounded factorial) experiments. He emphasized the need for a careful preliminary study of the relative efficiencies of the various types of designs before embarking on such experiments. The utility of a particular design (simple lattice, triple lattice, etc.,) depends among other things on the nature of the soil fertility distribution, the nature of the crop, availability of land, etc. Again, some of the designs, if they are to be at all satisfactorily analyzed without too much labour, require a very large number of plots as minimum for proper balancing and it is often beyond the resources of an agricultural experimental station to spare, say, 200 to 300 plots for a single experiment. A preliminary examination of the data of a few of the quasi-factorial designs in two groups of sets (two-dimensional simple lattice) for rice crop tried in Nagina, U.P., with plot sizes of 1/500 acre to 1/300 acre shows standard errors per plot ranging from 15 to 24%. This might indicate that there was not much gain in having gone in for these designs, which perforce necessitated such small-sized plots. In every case a careful preliminary study of the particular soil conditions, etc., is essential before these designs are adopted. There is no point in copying a particular design simply because it is found to have succeeded in some conditions in some localities. It was pointed out, however, that so far only some of the simplest of these designs have been adopted in our experimental stations.

6. Dr. P. V. Sukhatme, Delhi.

Dr. Sukhatme dealt with the uses of factorial designs in experiments in animal husbandry. He said that the classical method of experimentation in which a complex system of causation is replaced by a simple system in which only one factor is allowed to vary at a time not only does not work in problems in animal husbandry but is also altogether inefficient. He illustrated his point on a problem which has been receiving the attention of the Imperial Council of Agricultural Research for some time past, namely, of determining the relative magnitudes of the main causes of deterioration of the Punjab cattle when these are moved eastwards towards Bengal. Experiments reported in the past suggest that different breeds react differently to the change in climate and in food but as only one factor is studied at a time in these experiments they do not permit evaluation of the relative importance of different breeds and factors in the total deterioration. Obviously what is required is a factorial experiment on the more important breeds of the Punjab cattle in which not only will climate be varied but also food so that with two variants each in climate and food four treatment combinations are tried out simultaneously in the same experiment.

As regards the incomplete block designs he expressed the view that he was somewhat doubtful of the advantage of the square lattice designs in experiments with less than about fifty varieties. He had an occasion to examine the results of several experiments of the square lattice type laid out in the I.C.A.R. schemes, particularly the Paddy schemes, which seemed to show that the experimental error varied from 5 to 20% and consequently he thought that this aspect required further examination from the agricultural view-point.

He also visualized a few other applications of the principle underlying the incomplete blocks designs. In co-operative experimentation over a wide area it was customary to include a variety or treatment common to the whole area for the purpose of ascertaining the relative performance of different varieties grown in different centres. Often this practice resulted in the common variety putting up a poor performance in extreme centres thus vitiating the null-hypothesis that the varieties are equal. He suggested that it might be more proper if instead of including a common variety one were to lay down a condition that each pair of varieties occurred once in all centres. Similar situation arises in agricultural meteorology where a compromise appears to be called for in choosing between two alternatives (i) of observing the same plants week after week, and (ii) selecting fresh samples every week.

7. Mr. K. R. Nair, Calcutta.

Mr. K. R. Nair said that in the evolution of various confounded designs for factorial experiments and incomplete block designs for large scale varietal trials the present position is that theory has outrun practice. Recent work in the Calcutta Statistical Laboratory has opened up a new vista of mathematical problems in combinatorial algebra and finite geometry which is sure to attract the attention of statisticians and mathematicians. But there is great need for working out the practical efficiency of the new designs on the lines that Dr. Panse has been following at the Institute of Plant Industry, Indore.

The complete general solution of confounded designs for the s^n type of experiments, namely of n factors at s levels when s is a prime or power of a prime has been given by workers of the Calcutta Statistical Laboratory some time ago. But in the case of the more usual type of factorial experiment where the factors are all at different levels p, q. etc., the evolution of confounded designs was lagging behind. But in Calcutta we have been able to obtain general solution for this hitherto unsolved problem. Thus besides the elegant designs given by Yates for $2\times3\times3$ and $3\times2\times2$ experiments, quite a number of practically useful confounded designs can be now supplied to the agricultural field experimenter for experiments of simple types such as $2\times5\times5$, $2\times6\times6$, $3\times4\times4$, $3\times5\times5$, $4\times3\times3$, $5\times2\times2$, $5\times3\times3$, etc., and in general for $k\times s^n$ experiments in blocks of ks plots or $p^m q^n$ experiment in blocks of pq plots, etc. Also the statistical analysis of such experiments has been put on a systematic and convenient basis so that even non-mathematical workers may analyze the results of their experiments without difficulty.

Concluding Remarks.

The President (Sir T. Vijayaraghavacharya) wound up the discussion with the remarks that although he had been confounded with the statisticians' technical language he had no doubt that the new designs evolved by them with the help of highly mathematical tools deserved a fair and intense trial by practical workers in agricultural research so that a set of efficient designs could be finally selected which would be suitable to various crops and soils of India. He pleaded for a friendly and understanding co-operation between mathematicians, statisticians and the agricultural field experimenters in this important task.

II. CHROMATOGRAPHIC ANALYSIS.

(*Section of Chemistry.*)

Dr. M. Qureshi, Hyderabad-Deccan, presided.

Mr. G. B. Ramasarma, Bangalore.

Though the method of chromatographic analysis was developed by Tswett as early as in 1905, it came to be widely used for the separation of difficult mixtures of organic compounds, particularly the chloroplast pigments, only from the year 1931. Since then, a number of naturally occurring carotenoid pigments have been isolated and studied by employing this elegant method and it may be said that the history of the chemistry of this important class of pigments begins from that date. Subsequently, the method has been adopted for the separation of colourless organic compounds and in recent years, for inorganic compounds also. It has now become an indispensable routine method in the hands of the biochemist and the organic chemist.

The first of a series of investigations on the occurrence and distribution of carotenoid pigments in Indian fruits and vegetables, undertaken in the Biochemistry Department of the Indian Institute of Science, Bangalore, referred to the pigments of the mango fruit. It was shown that nearly 90% of the carotenes of this fruit consists of the beta-isomer which is twice as active as any of the other provitamins A. The remaining 10% is accounted for by a 'carotene' which is optically inactive but whose exact chemical nature is not known. It showed absorption maxima at 457 and 480 mμ in carbon disulphide solution. The xanthophylls, which constitute 20–40% of the total carotenoid pigments of the fruit, exist in the form of esters.

In the course of a study on the absorption of subminimal doses of β-carotene by vitamin A-deficient rats, this method has been employed with success for the separation of the faecal carotene from associated non-carotene pigments and thus it was possible to estimate quantitatively the amounts of carotene excreted by the experimental animals.

Details about the materials used and actual technique employed for the analysis of carotenoid pigments were described.

III. INDUSTRIAL PLASTICS.

(Section of Chemistry.)

DR. M. QURESHI, Hyderabad-Deccan, presided.

1. DR. H. K. SEN, Ranchi.

Opening Remarks.

Plastics may be widely defined as 'materials that can be formed or moulded' and would cover ceramics, glass, cements, casein, rubber, bitumen, and scores of natural and synthetic resins. Plastics in the wider sense have been used in industries from time immemorial but industrial resin plastics, to a survey of which the present paper is restricted, is comparatively of very recent origin. Shellac is the oldest resin plastic which was first used in the manufacture of gramophone records in 1877 and still reigns supreme in that field. The annual production of lac is 30,000 to 40,000 tons while the production of all the synthetic resins taken together is about 150,000 tons. Shellac is the only thermoplastic resin which when suitably modified by accelerators behaves like a thermo-setting resin. Its use is being extended from gramophone records to electro-technical goods, vulcanite substitutes, etc., in the form of moulded goods and insulation boards, materials of construction, etc., in the form of laminated boards. An intensive study of the various possible modifications of lac and its components is yielding a variety of resins from this one natural product each best suited for a definite application. The resin that is not a single entity but nature's own peculiar blend, a border-line of thermoplastic and thermo-setting resins, is capable of being resolved and re-formed to yield the equivalent, at a least a near equivalent, of almost any of the synthetic resins which are simpler in construction. Casein plastics that started their trail in 1904 have a restricted application to articles that can be fashioned from sheets, rods and tubes and cannot be successfully used as moulding powders due to high shrinkage during moulding and irregular hardening in articles of complicated design. The raw materials for casein plastics are mainly milk to provide raw casein and formalin for hardening the sheets, rods and tubes. The annual world production of casein plastics is about 10,000 tons mostly for buttons, buckles, beads, game counters, etc. Recent developments in this field refer to the use of vegetable proteins from soya-bean, corn, coffee-seeds, etc., either alone or in combination with synthetic resins. Vegetable proteins have also been used as adhesives for laminating sheets of paper fabrics, etc., but the water-resistance of such products is low.

The world output of cellulose acetate and cellulose nitrate plastics amounts to about 40,000 tons a year and the applications cover a very wide region, viz. handles, spectacle frames, toys, lamp shades, combs, etc. Methods of manufacture are briefly described. While cellulose nitrate plastics are mostly made in sheets, rods and tubes, acetate plastics are marketed as injection and compression moulding powders, films and foils. Recently, benzyl cellulose and ethyl cellulose have been developed, chiefly for injection moulding and for adhesives in safety-glass.

The history and development of phenolic plastics, theories of resinoid formation, and recent advances have been briefly reviewed. Among synthetic resin plastics phenolics occupy a pre-eminent position as regards the total world output (about 60,000 tons), versatility of applications and progressive improvement in quality as a result of well-planned and executed research. Recently, engineering materials, like gear-wheels and bearings and chemical equipment are also manufactured from phenolics; the largest use is however still in the electrical insulation industry.

Alkyd resins which are not very important from the point of view of the plastics industry are also briefly reviewed.

The vinyl type of resins recently developed commercially are the poly vinyl resins, styrol resins and acrylic resins which are all thermoplastic. Although they have not yet attained considerably large output, they are the resins of the future as they possess extraordinary properties as regards hardness, toughness, clarity, etc., and are ideally suited for injection moulding.

Cumarone and indene resins representing the cheapest types of synthetic resins suitable as binders in compositions for floor tiles, etc., are also briefly reviewed.

Theories of resinification, developments in moulding equipment and technique and the future of the industry are outlined.

2. Dr. K. VENKATARAMAN, Bombay.

Speaking on 'Plastics in the textile industry', Dr. K. Venkataraman said that they belonged to two distinct groups: (*i*) fibres, such as casein fibres and Nylon, made from natural or synthetic resins; and (*ii*) resinous materials applied to cotton, rayon or other textiles. Fibres could, therefore, be composed entirely of plastics, or in order to modify their properties textile yarns and fabrics could be treated with plastics.

Following an account of the chemistry and technology of Nylon, and a general survey of the natural and synthetic resins employed for the modification of textile fibres, the production of creaseless cotton fabrics, which is in principle the removal of the plastic nature of the fibres, making them resilient, was described in detail. The choice of a resin from among numerous synthetic resins available had to be based on various specific requirements. Anti-creasing methods were of special value for rayon, the strength of which, particularly in the wet state, could thus be considerably increased; delustring to the desired extent could also be produced simultaneously. The methods by which the efficiency of the anti-creasing process could be examined were also described.

3. DR. J. L. SARIN, Lahore.

IV. MANUFACTURE OF SYNTHETIC DRUGS IN INDIA.

(Section of Chemistry)

Dr. M. Qureshi, Hyderabad-Deccan, presided.

1. Dr. K. Venkataraman, Bombay.

Opening the symposium on 'the manufacture of synthetic drugs', Dr. K. Venkataraman said that the manufacture of synthetic drugs and of organic fine chemicals in general depended on the establishment of a dyestuff industry, as evidenced by the success of Bayer, Ciba and Sandoz as producers of synthetic drugs on account of their being primarily dyestuff manufacturers. The few medicinal chemicals, which are being manufactured at present in the country and in which at least one stage of synthesis is involved, are either at non-competitive prices or are from imported chemicals. The two most urgent problems were to carry out a survey of the synthetic drug consumption, on the basis of which a programme of production could be planned; and the manufacture of the essential inorganic and organic raw materials, intermediates and solvents. Since many of the newer pharmaceuticals are based on coal tar products, this would be contingent on the development of the dyestuff industry, for which more or less the same basic chemicals would be required on such a scale that their economic preparation would become inevitable. The necessary plant must be imported in the first instance, although in the long run, a stable chemical industry must be self-contained for its supply of chemical plant, of which the varied types demanded by modern chemical operations must be fabricated in the country. On account of the many advantages, such as the setting apart of units of equipment for the preparation of a single chemical or a related group of chemicals, schemes of production should be carefully co-ordinated and a few large factories in suitable locations established rather than the present indiscriminate and unorganized production of miscellaneous chemicals in numerous small factories. Taking as a model the survey of the inorganic and organic raw materials, for a dyestuff industry for a 15-year plan of production of a range of dyes, which the textile and other colour using industries would regard as their minimum requirements, which is now in progress under Government auspices, a similar survey for synthetic drugs should be immediately undertaken. Classifying the essential drugs into a few main groups and taking individual examples, the raw materials required were discussed. The dyestuff industry, which would supply a large number of the necessary raw-materials and intermediates for synthetic drugs, should not only be established as early as possible, but it should also be so organized that it functions as a key industry, with the aid of which the synthetic drug and fine chemical industries can develop.

2. Dr. R. P. Patel, Baroda.

3. Dr. B. C. Guha, Calcutta.

4. Dr. K. H. Hasan, Hyderabad-Deccan.

5. Dr. P. B. Sarkar, Calcutta.

V. PHYSICAL AND CHEMICAL PROPERTIES OF CLAYS AND BENTONITES.

(*Section of Chemistry*)

DR. M. QURESHI, Hyderabad-Deccan, presided.

1. PROF. J. N. MUKHERJEE, Calcutta.

Introductory Remarks.

The word clay has been used in various senses. The farmer would refer to a soil as a clay when it is heavy to work and sticky in wet and lumpy in dry weather. The brick-maker's clay is a subsoil which can be baked to form bricks while under the same name the potter uses a finer material from which stones and gravel have been carefully removed and which has the requisite plastic properties. The mineralogists' conception of clay comprises a group of minerals containing O, Si, Al and/or Fe as major constituents. The soil chemist's definition lays emphasis on the particle size and by clay, or rather the 'clay fraction', he understands the inorganic material of soil (bentonite) having particles smaller than 2μ. It is now recognized that most of the physical and chemical properties of soils and bentonites depend to a large extent on the nature and amount of their clay fraction.

Both clays and bentonites are electrochemical or polar substances and are formed by the weathering of rocks. The reactions involved in chemical weathering are mainly of an electrochemical character in which the *p*H of the medium and climatic factors, e.g., rainfall, temperature and natural vegetation plays a part. Bentonites have probably a volcanic origin. The clay fraction of both soils and bentonites mainly consists of secondary silicate minerals with which may be associated varying proportions of the oxides of Si, Al and Fe. The more common clay minerals belong to the main groups kaolonite, montmorillonite and micas. The bentonites mainly contain montmorillonite minerals.

The fundamental unit of structure of these minerals is tetrahedron with Si at the centre and O at the four vortices. Several SiO_4 of the regular SiO_4 tetrahedra are interlinked by each of three basal O atoms forming a hexagonal Si-O-Si layer.

In kaolinite, the vertices of these linked tetrahedra all point the same way and are attached to Al atoms. which are linked on either side to O and OH giving rise to the so-called gibbsite layer. The pattern continues indefinitely till the broken edge is encountered.

The presence of micas in the clay fraction of soil has been established after some controversy. In the micas trivalent Al replaces tetravalent Si in every fourth tetrahedron of the Si-O-Si layer; the vertices of the tetrahedra belonging to two such layers are crosslinked by Al atoms and OH groups are incorporated to satisfy the octahedral co-ordination of Al. The resulting double sheet has a negative charge which is balanced by cations (e.g., K^+ in muscovite) incorporated in between them.

There is some difference of opinion regarding the structure of montmorillonite. Hoffman *et al* suggested a symmetrical structure in which the two Si-O-Si layers are situated one on each side of a bauxite layer giving rise to a composite mineral sheet.

Isomorphous replacements are very common in the clay minerals. Further, different clay minerals are often found to occur in varying proportions in the various subfractions mechanically separated from the same entire clay fraction. For these reasons and owing to the association of free silica and sesquioxides it is not possible to identify the mineral constituents of the clay fraction, on the basis of total analysis alone. A close relation is however often found to exist between the chemical composition and a variety of physical and chemical properties of clays, thus: swelling, viscosity, dispersibility, heat of wetting, base exchange capacity all become pronounced with an increasing SiO/R_2O_3 ratio of the clay fraction. While this ratio as a single valued soil constant is apparently of importance, its value as an index to base exchange characteristics should not be overemphasized. Thus subfractions of the clay fraction have been found in this laboratory to constitute exceptions to this correlation. It is more truly a rough criterion for the *ensemble*, i.e., the entire clay. For the identification of the individual mineral constituents of the ensemble recourse is generally taken to physical methods, the most important of which is X-ray analysis. Studies of temperature dehydration curves and optical properties also provide useful criteria. These methods are however not without their limitations. Direct microscopic examination of the clay fraction is not possible. However, at least one of the refractive indices can be accurately determined by depositing the particles, usually flat shaped on the object glass from a concentrated suspension. Another useful technique is to orient the particles floating in the suspension with the help of an electric field and measure the electrical birefringence.

The electrochemical properties of clays and bentonites have been the subject of detailed investigations in this laboratory by Dr. R. P. Mitra, Dr. S. P. Raychaudhuri, Mr. B. Chatterjee, Mr. S. K. Mukherjee and others. These studies have opened up several fresh methods of characterizing the hydrogen clays, hydrogen bentonites and their salts. And a method that is promisingly good consists of comparing the titration curves of the clay fraction with those of pure specimens of the minerals. Dr. R. P. Mitra working in the speaker's laboratory has been able to identify kaolinite in certain Indian soils with the help of this technique.

Among the more important physical properties of clays and bentonites are plasticity, viscosity, shrinkage, swelling and thixotropy. The bentonites are highly thixotropic. Their rheological properties find useful application e.g. in drilling muds, etc. Gel strength and thixotropy are interrelated colloidal phenomena which depends on the formation of some sort of a structure, the latter being conditioned in its turn by the chemical nature, size, shape, concentration, solvation and the electric charge of the particles. Evidence of structure formation in dilute hydrogen bentonite and the resemblance of their properties with those of typical organic colloidal electrolytes have been obtained in the speaker's laboratory.

A second group of closely related properties are those associated with the phenomena of base exchange which are of fundamental interest to soil science and scientific methods in agricultural practices. It has been long known that mono- and bivalent cations can be displaced more or less readily from soils and clays by the cations of an added acid, base or salts. Consequently base exchange studies have a definite place in the routine analytical work of the agricultural chemist and in relation to properties of irrigation, land reclamation and erosion control. The nature and amount of the exchangeable bases govern many of the physical and chemical properties of clay and of soils. The colloid chemical aspects of base exchange, e.g., its relation with flocculation, deflocculation and the electric charge of the particles have been and are active themes of research. The mechanism of base exchange is however not fully understood and a quantitative formulation is yet lacking. A number of equations based on the mass action law or adsorption isotherm have been set up, none of which has been found to be entirely satisfactory. Mineralogists are generally inclined to the view that the exchange cations are integral parts of the clay lattice. The electrical double layer and adsorption of ions however play a very important part in determining base exchange.

Base exchange and related properties of clays and bentonites are in reality manifestations of their electrochemical nature whose main feature is a well developed acid character which consequently form a connecting theme in the study of their properties. Hydrogen clays and hydrogen bentonites obtained by electrodialysing natural clays and bentonites or repeatedly leaching them with dilute mineral acids show this acid character to a marked degree. The work of Dr. R. P. Mitra and Mr. B. Chatterjee and others in the speaker's laboratory has revealed that their colloidal solutions are definitely polyphase acid systems and show features which are different in several essential aspects from those of acids in true solution. Their titration curves with different bases have different forms. Contradictory features are shown by the potentiometric and conductometric titration curves with a fixed base. The total acidity calculated from the titration curves is not a fixed quantity but depends on the nature and concentration of cations present and consequently it is not possible to apply the concepts of degree of dissociation and dissociation constant to such a system. Their interaction with bases and salts reveals a number of common features which can be used to characterize them. A regular and an irregular cation effect depending on the *p*H of the system and representing the order of reactivity with cations have been recognized. In addition there is what may be called a *p*H effect. They all show characteristic inflexion points and simulate in some aspects a weak acid, in others strong acid. Some of them show a monobasic, some a diabasic character. Also the same hydrogen clay or bentonites may behave as a monobasic acid under one set of conditions and as a dibasic acid under another set of conditions. These complex features of their behaviour admit of a consistent explanation in terms of the nature of the primarily adsorbed ions, of the secondary adsorption of added cations and of the structure of the double layer.

The differences in electrochemical properties e.g. in the form of the titration curves of hydrogen clays and hydrogen bentonites obtained from various soils and bentonites which have been observed by us, are expected to be useful in their characterization and classification. One interesting application of these differences may be mentioned. It has been observed that the hydrogen bentonites give two types of curves and definite correlations exist between the two types of curves and several viscous properties of the bentonites. Further, field trials have shown that the dibasic bentonites are more suitable as drilling muds than the monobasic ones. The yield value viscosity, thixotropy and wall-building properties of the suspension show a striking parallelism with the buffer capacity—the same succession of, and in some cases coincident, maxima and minima are observed and the anomalous viscous properties show two maxima where the bentonite is dibasic in character and one maximum for monobasic bentonites. This close parallelism throws a great deal of light on the probable factors which govern the viscous properties of such systems.

This introduction to this discussion is intended to show how intimately the crystal structure and the chemical nature of the anion groups are interwoven with the physical and chemical properties of these systems.

2. Mr. A. Reid, Khodaung (Burma).

Introduction.

(1) In 1933 the Burmah Oil Company began an investigation of Indian bentonites with a view to finding one suitable for use with drilling fluids, for which purpose bentonites were then, as now, largely being used in the U.S.A. These investigations led to the production from a bentonite found in the Jammu province of Kashmir of products suitable for use with drilling fluids. This brief note covers the salient points of these investigations.

Properties of Raw Kashmir Bentonite.

(2) Crude Kashmir bentonite has a soft soapy feel, varies in colour from cream to grey (a black variety has been reported) and like most bentonites exhibits sub-conchoidal fracture, newly exposed surfaces exhibiting a dull resinous lustre. The specific gravity varies from 2·60 to 2·65, depending on the amount of fine grey sand contained in the mass.

(3) A sediment volume test performed with 2 gms. of ground bentonite dispersed in 100 ml. of water shows a gel volume of only 8·0 ml. whereas American bentonites show 20 ml. or even more. Since, according to Freundlich, the extent of sedimentation is related to the degree of swelling it would appear that Kashmir bentonite shows relatively little swelling without suitable treatment.

(4) A MgO test put forward by Silica Products Corporation of the U.S.A. confirms this assumption. Whereas Kashmir bentonite shows under the conditions of the test a gel volume of 11·5 ml. Wyoming bentonite gives a reading of 94. The test is intended to indicate whether a material is a bentonite or not, bentonites being said to give a gel volume of 50 ml. or over. It is quite clear from subsequent work that this test evaluates only sodium or potassium bentonite and gives an entirely erroneous impression of calcium bentonites, such as the Kashmir one in its original state.

(5) A base exchange analysis of Kashmir bentonite shows the following:—

	Na & K	Mg	Ca	Total.
Milliequivalents per 100 gms. of bentonite	1·6	17·1	65·8	84·5

(6) It will be clear that Kashmir bentonite has an appreciable amount of exchangeable calcium and it would seem that, if the swelling of the bentonite is to be improved, the most suitable means would be to replace the exchangeable calcium by sodium, in other words to make it a sodium bentonite. It is, of course, well known that sodium bentonites swells much more than calcium bentonite.

Treatment of Kashmir Bentonite.

(7) At first attempts were made to replace the exchangeable calcium by treatment with caustic soda. Results were poor. A fraction of the bentonite only was peptised and the remainder settled with the sand at the bottom of the containing vessel. This result was obtained over a range of pH of the suspension from 9·0 to 12·0.

(8) Attempts were then made to carry out the reaction with sodium carbonate. At first results were poor. It was then discovered that the base-exchange reaction was considerably facilitated by suspending the raw bentonite in water and allowing it to stand at least 12 hours before adding the sodium carbonate. Using this procedure very stable suspensions of the bentonite were prepared and when these were dried and powdered the products obtained behaved on addition to drilling fluids almost as well as those marketed specially for the purpose in America.

(9) A further improvement was obtained when in addition to treatment with 5% of soda ash by weight of bentonite, 0·4% of common salt was also added. It appeared that if sufficient soda ash were added to complete the base-exchange reaction the pH was too high for maximum swelling. By combining soda ash and salt treatment the base-exchange went to completion and products superior to American bentonites were obtained.

(10) It happened that we required a bentonite at the time which would produce a very considerable increase in the viscosity of drilling fluids when added in very small proportions. Research showed that the addition of 5% by weight of magnesium oxide to the sodium bentonite gave a substance which not only increased the viscosity of drilling mud

in rather remarkable fashion but improved the stability of the mud and its 'plastering' properties to a marked extent.

(11) Attempts were also made to carry out the base-exchange process with sodium metasilicate in place of soda ash. These failed, results being much the same as for caustic soda. Treatment first with sodium metasilicate and then with salt was likewise unprofitable. It was found, however, that potassium carbonate gave results almost as good as those with sodium carbonate and that rather more than half the quantity of K_2CO_3 was required for best results. No good results were obtained with magnesium carbonate.

(12) The preparations made with soda ash, salt and magnesium oxide have been christened 'Bentogels' and are thus referred to below.

Full-Scale Preparation

(13) A difficulty was met with in the early stages of full-scale preparation of Bentogels. When the soda ash was added to the suspension of bentonite contained in a steel tank the thickening indicative of the base-exchange reaction in progress was not observed; a degree of peptisation was all that was achieved. Dr. Evans observed that if samples of the treated bentonite were removed and placed in glass vessels they formed a gel, which on drying was quite equal to a similar product made entirely in glass or procelain apparatus. The speaker was later able to show that this failure to gel was due to the presence in the suspension of ferric hydroxide in colloidal suspension, which formed when the soda ash came in contact with the sides of the tank.

(14) Accordingly in subsequent trials the soda ash was dissolved in the minimum of water in a pail and mixed with some of the bentonite suspension to form a paste which was slowly incorporated in the main mass of the suspension. Satisfactory gelling was obtained and the dried product was quite up to standard.

(15) Other problems remained. Sodium bentonite when added to water forms 'balls' of a high degree of adhesiveness and its admixture with mud on a large scale tended to be awkward. By increasing the salt content a product which did not 'ball-up' in water but conferred the desired properties on drilling mud was obtained.

(16) *It was also found that if a drilling mud in circulation were* treated with soda ash and later with crude Kashmir bentonite a result was obtained fully equivalent to a treatment with specially prepared sodium bentonite.

(17) By incorporating small quantities of a local gum in the bentonite suspension after treatment with soda ash and salt, a product was obtained which could be used direct as a drilling fluid. For certain purposes such 'mud' with its low specific gravity (ca. 1·1), high fluidity, moderate gel-strength, resistance to salt water and its excellent wall-building properties, was ideal and wells drilled with it in various areas were drilled quickly and without difficulty.

Other uses of Bentogels.

(18) In the laboratory Bentogels are used as cleansers and they are superior to soap in removing grease, dirt and bitumen stains from the hands or from cloth. One of them has actually been used as a base for mud packs for a beauty parlour!

(19) Bentogels may be used also with cement to improve plasticity and reduce shrinkage, with moulding sand and with pottery clays to increase plasticity and with bitumen to form bituminous emulsions. They may be used with paper for de-inking purposes and in medicine they may be used as the base for such products as 'antiphlogistine'.

Acknowledgment.

(20) Much of the work on Bentogels is due to Mr. D. R. Mitra B.Sc., of the Assam Oil Co. Ltd., Digboi and the speaker's thanks are due to him for co-operation in preparing this paper.

3. Dr. S. P. Raychaudhuri, Dacca.

Variations of the clay-forming minerals in different soil types.

The clay fractions of the soils, that is the aluminosilicate materials which have been produced by the weathering of the rock-forming materials, are the active constituents of soils and all the inherent differences of physico-chemical properties of soil types are essentially due to the differences existing in the clay fractions of the soils. The clay fractions of the soils, by internationally agreed nomenlature, are assumed to be particles of diameter ·002 mm. or less. Actually, however, X-ray investigations have shown, that the particles are not of spherical dimensions but of platy structure. In other words, from structural point of view, these particles have been formed, as it were, by the superimposition of silica sheets and of alumina sheets. The clay fractions, by their nature, are essentially of two types, viz., one of beidelite and montmorillonite group with high base-exchange capacity, and the other of kaolinite with low base exchange capacity. In the beidellite and montmorillonite group of minerals the structure is made up of three or more sheets of silica and alumina, and the distance between these sheets is of the order of 1·5 mμ, so that exchangeable bases can be extrenched between these sheets. On the other hand, in the case of kaolin group of minerals, the structure is made up of only one sheet of silica being superimposed on a sheet of alumina and the distance between these sheets is only about 1 mμ, so that there is not much chance of exchangeable bases being exclosed between these sheets and consequently these group of minerals are poor in base exchange capacity.

In India, as in other tropical countries, various types of soils with characteristic physico-chemical properties and often of different colours occur. At many places these soil types occur in very close localities. Physico-chemical examination of these soil types and of the clay fractions at the Dacca University have shown that the fundamental differences lie in those of the clay fractions. For example, profile samples from a red soil type and a black cotton soil occurring within a distance of about two miles from each other near Sravanampatti Hillock at Coimbatore has revealed that the percentages of clay fractions occurring in the soil types are very similar. The silica-alumina ratio of the clay fraction of the black soil is higher than that of the red one. Also the black clay possesses much higher base combining capacity and much greater moisture holding capacity than the red clay. The percentages of organic matter in the black soil were found to be somewhat higher than in the red, but not enough to explain the enormous differences in agricultural values and of physico-chemical properties of the soil types.

Mineralogical examination of these contrasted soils has revealed that the red soils are richer in percentages of ferromagnesium rock-forming minerals than the black soils. Examination of the dehydration curves of clay fractions separated from the soils has revealed that the black soils which are more productive are richer in the beidellite type of clay forming minerals whilst the clay fractions of the red soils are comparatively richer in the kaolinitic type of clay-forming minerals. The buffer curves of the clay-fractions obtained from the black soils are steeper than those of the clayfractions obtained from the red soils.

4. Dr. R. P. Mitra, Calcutta.

The electrochemical properties of clays and bentonites.

The central connecting theme in the electrochemistry of clays and bentonites is their dominant acid character which gives expression in their capacity to bind or retain bases. Apart from a vague and general recognition of this acid character its quantitative formation has long been lacking. Systematic studies of hydrogen clays and hydrogen bentonites have been carried out by the speaker and others under a scheme of research financed by the Imperial Council of Agricultural Research. The following is a summary of the main results obtained.

Colloidal solutions of hydrogen clays and hydrogen bentonites are definitely polyphase acid systems. While the sol has free acid usually of the order of 10^{-4} N its ultrafiltrate shows an almost neutral reaction. Mobile H^+ ions associated with the particles are responsible for the observed H^+ ion activity. When a neutral salt is added to the sol, acid is liberated. At the same concentration, different salts liberate acid (i.e. titratable acid) in the order (Ba>Ca>Na) of electrical adsorption of the cations. The total reacting acid or the base exchange capacity (b.e.c.) per gramme is also not a fixed quantity but depends on *p*H and cation effect. Usually the greater the *p*H the greater is the b.e.c. The *cation effect* is illustrated by (*a*) the dependence on the cation of the base of the b.e.c. calculated at the inflexion point of the titration curve and more strikingly at a fixed *p*H e.g., 7·0; (*b*) by the much higher b.e.c. obtained on titration in the presence of a large concentration of a neutral salt than in its absence; (*c*) by the different effects of various neutral salts having a common anion. In the absence of salts the b.e.c. decreases in the order $Ca(OH)_2 > Ba(OH)_2 > NaOH$ which however changes to $Ba(OH)_2 > Ca(OH)_2 > NaOH$ in the presence of a fixed concentration of the corresponding salts. The reversal in the relative effects of Ba^{++} Ca^{++} ions have been traced to the differences in the *p*H region in which the acid-base reaction takes place. In the presence of the salt the intreaction with the greater proportion of the base $Ba(OH)_2$ or $Ca(OH)_2$ up to the inflexion point occurs in the acid region, usually between *p*H 3·5 and 5·5, while in the absence of the salt it is mainly confined with the range of *p*H 5·5 to 6·5. In the presence of salts the cation effect is regular, in the sense that it follows the lyotrope series and is determined by the order of the adsorption of the cations together with their hydration envelopes. At the comparatively high *p*H in the absence of salts the cation are probably absorbed in a dehydrated condition which accounts for the irregular or specific cation effect, irregular in the sense that it does not follow the lyotrope series, operating under these conditions. The regular and specific cation effects have been observed with subfractions of the hydrogen clays having equivalent spherical diameter ranging between specified limits and separated from the same entire clay fraction and also after hydrogen clays have been treated by methods aiming at the removal of their free inorganic oxides. The cation effect also impresses itself on the form of the titration curves. The curves with different bases have different forms. While the baryta and calcium hydroxide curves (potentiometric) have usually a flat initial run and thus have a strong acid character, the caustic soda curves generally show a comparatively sharp initial rise and in this respect resemble that of a weak acid. The features of the conductometric curves are at direct variance with those of the potentiometric curves. Thus the slopes of the descending portions of the conductometric curves are in the order; $NaOH > Ba(OH)_2 > Ca(OH)_2$ indicating a stronger acid character of the NaOH curve compared with the $Ba(OH)_2$- or $Ca(OH)_2$ – curve. Somewhat different types of curves have been obtained in titrating hydrogen clays and hydrogen bentonites isolated from the entire clay fraction of different Indian soils and bentonites. Such differences are likely to be of importance in the characterization and classification of soils and bentonites. The NaOH curves of the hydrogen clays are of three types: Week monobasic, which is most common; weak dibasic; and strong dibasic. Their $Ba(OH)_2$ and $Ca(OH)_2$ curves are of four types each: strong monobasic, the most common type; strong dibasic; weak monobasic; and strong monobasic but showing an actual lowering of the *p*H on the addition of the base in the initial stages of the titration.

The hydrogen bentonites give two types of NaOH-curves, weak monobasic and strong dibasic. Hydrogen clays and hydrogen bentonites having particle size within specified limits and mechanically separated from the same entire hydrogen clay or hydrogen bentonite often show nearly the same type of titration curves. Differences have sometimes been observed and in such cases the chemical composition, base exchange capacity and certain other optical properties are also materially different from the other fractions. The base exchange capacity per gramme of the various subfractions generally increase with diminishing particle size. Calculated per sq. cm. of the external surface, however, the b.e.c. usually increases with the size of the particles indicating that the particles have considerable inner surfaces and/or fresh layers are exposed as the interaction with the base proceeds.

5. Mr. B. Chatterjee, Calcutta.

The role of aluminium ions in the interaction of hydrogen clays.

The interaction between hydrogen clays and neutral salts give rise to both H^+ and Al^{+++} ions in the neutral salt extracts. There is no unanimity of opinion regarding the mechanism by which Al^{+++} ions are brought into solution. A direct exchange of Al^{+++} ions for the cations of added salts is suggested by some[1, 2] while others[3, 4, 5] hold that Al is brought into solution by a secondary dissolution of Al_2O_3 present in the clay. Paver and Marshall [6] consider that a direct exchange of both H^+ and Al^{+++} ions for the cations of added salts takes place. Previous investigations from this laboratory[7, 8, 9] show that (i) the free acidity of the hydrogen clay sol constitutes a small fraction (5% to 10%) of its total acidity. (ii) the total acidity of the hydrogen clay sol is greatly increased on the addition of neutral salts, and (iii) the supernatant liquid above the coagula of the sol and salt mixture contains a considerable amount of neutralizable acid.

The mechanism by which Al^{+++} ions are brought into solution and the contribution of the Al^{+++} ion towards the free and total acids of hydrogen clay sols have been discussed in the paper. At low concentrations of $BaCl_2$ the total acidity of the supernatant liquid cannot be wholly accounted for by the amount of Al present. This excess has been attributed to H^+ ions. Further, with very low concentrations of NaCl only H^+ ions are displaced into the intermicellary liquid. The titratable acidity of the $BaCl_2$ extract and the amount of Ba^{++} adsorbed are in fair agreement. At the same *pH* the amount of Al^{+++} ions brought into solution by HCl constitutes a small fraction of that liberated by $BaCl_2$. The *p*H of the hydrogen clay and $BaCl_2$ mixture is not of much consequence in determining the amount of liberated Al at a given concentration of Ba^{++} ions. The amount of displaced Al is not reduced on the removal of free sesquioxides from the clay but on the contrary an increase (calculated per 100 gm. of the residual colloid) is observed.

The above evidences suggest that the major portion of Al displaced by neutral salts should not be attributed to any dissolution of Al_2O_3 by the free acid developed in the interaction between a hydrogen clay and neutral salts. A direct exchange of both H^+ and Al^{+++} ions for the cations of the added salts offers a more plausible explanation.

The form of the potentiometric titration curves of hydrogen clay sol with bases, changes when a salt has been added and with increasing concentrations of the salt the titration curves become progressively characteristic of a strong acid. The titration curves of the clear supernatant liquid above the coagula of the sol and salt mixtures have forms widely differing from that of the pure sol and show features which have been observed with solutions of aluminium salts (Britton,[10]). Both H^+ and Al^{+++} ions are present on the surface of the colloidal particles, H^+ ions constituting a small fraction of the total. On the addition of neutral salts a portion of these ions (H^+ and Al^{+++}) is displaced into the intermicellary liquid while another portion remains associated with the colloidal particles. With increasing salt concentrations more and more ions (H^+ and Al^{+++}) are displaced, but fresh ions are brought into a reactive condition. The amount of ions remaining associated with the colloidal particles, i.e., the difference between the total acidity of the sol and salt mixture and that of the supernatant liquid above the coagula of the sol and salt mixtures, does not differ greatly on the addition of salts or from the total acidity of the sol itself. This quantity appears to depend on the displacing power of the cation of the salt, and an equilibrium between the ions in the intermicellary liquid and in the double layer is indicated.

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VI. MANUFACTURE OF SCIENTIFIC INSTRUMENTS IN INDIA.

(*Sections of Chemistry, Physics, and Medical and Veterinary Research.*)

DR. M. QURESHI, Hyderabad-Deccan, presided.

1. M. SREENIVASAYA *and* M. A. GOVINDA RAU, Bangalore.

During the past few months the manufacture of scientific instruments in India has been receiving the earnest attention of the scientists in the country. They have begun to experience an ever-increasing shortage of supplies with regard to scientific instruments and laboratory chemicals, whose import is fast dwindling on account of the worldwide conflict. Just at a time when the country has launched upon a programme of intensive industrialization, it is regrettable that the supplies of the scientific and industrial accessories so essential for the prosecution of pure and applied research, are becoming increasingly scarce and difficult to obtain. This circumstance is very largely due to the fact that this country, short-sighted as it has been in all other respects, has so far had no concrete plan for its industrialization.

The scientific instruments industry constitutes one of the fundamental key industries of a nation. It provides the necessary tools for the training of scientists and technologists who are needed for the creation, development and maintenance of industries. Scientific instruments provide the necessary equipment for the prosecution of research on which the fabric of industrial advancement depends. The control of the unit processes in industry and the standardization of the products are dependent upon the application of suitable scientific instruments, while they are also needed for the diagnosis and treatment of diseases. Recent events have demonstrated that the problems of national defence against the methods of modern warfare are largely problems of instrumentation. For purposes of discussion, scientific instruments may be grouped into the following classes:—

(1) Instruments for purposes of demonstration and practical instruction in schools and colleges.
(2) Instruments needed for pure and applied research.
(3) Instruments required for the control of technical processes and the standardization of industrial products.
(4) Instruments for the diagnosis and treatment of disease.
(5) Instruments needed in connection with operations for national defence.

It will be observed that for most of the important items listed above the country is now dependent upon foreign supplies. The responsibility for this extremely regrettable state of affairs has to be shared by three groups; first, by the Government who have not encouraged the establishment of this key industry; secondly, by the scientists, technologists and the industrial magnates, who might have organized themselves to secure the elementary precaution of self-sufficiency with regard to their tools of research and industry; thirdly, the several firms of standing who have pioneered the scientific instrument trade in this country. In all progressive countries the trade is made to realize their responsibility in producing the goods as far as possible, and enlightened Governments help them to achieve this object through subsidies, tariffs, and other forms of support.

This is a propitious moment for launching upon a ten-year plan for the development of this industry and in this task, all the three groups of bodies should co-operate, the Government by extending their financial support, the scientists, by placing their experience at the disposal of the industry and through research, and the trade by organizing the manufacture of these instruments within the country to an ever-increasing degree in order to attain such a degree of self-sufficiency as to render research and industry independent of unsettled conditions of war.

The principal difficulty which faces the manufacturer of scientific instruments in this country is the lack of the essential raw-materials. A scientific instrument consists of several fundamental units which may be grouped as follows:—

Bearings including jewells, Springs of all kinds, Bimetals, Pivots, Photocells, Thermopiles, Rectifiers, Permanent magnets Optical and Laboratory Glass, Electrical accessories, Insulating cements, Enamels, Porcelains and glasses, Resistance wires, Special alloys like bronzes, Heat and corrosion resistance steels and other materials of construction.

The fundamental units and special materials of construction will have to be rendered easily and readily available at reasonably inexpensive rates, to the manufacturer of scientific instruments. He should not depend upon foreign manufacturers for these raw materials. The existing industries and workshops should co-operate in the production of some of these units as a matter of national duty and help to build up the industry which is going to pay them dividends in the form of research service.

At the moment there are a few centres and individuals who may be entrusted with the task of developing some of the lines. The problem of making magnets, the making of optical glass, the manufacture of bimetals and springs of various alloys and in various shapes and sizes, the problem of making resistance wires like nichrome and the study of heat and corrosion resistance steels,—all these require long range research. These investigations have to be financed by the Government of India and the different problems entrusted to various centres which are best suited for the investigations.

The actual manufacture of a scientific instrument itself is not a very complicated problem; the principles underlying the construction of most of them are well-known and any modifications or alterations to suit the exigencies of particular circumstances are easily introduced by the instrument maker. Our mechanics are extremely clever and resourceful.

The Government should maintain a central standards research Laboratory whose principal task will be to standardize the instruments manufactured by the industry. This laboratory will also conduct research on problems of instrumentation. The scientific instruments committee which has been constituted under the auspices of the Board of Scientific and Industrial Research has already made several grants to explore the possibility of making certain types of scientific instruments and equipment in the country. But these efforts which are commendable in themselves, do not touch at the root of the problem. Our energies should be directed towards the manufacture of the fundamental units and materials of construction on which alone can be laid the solid foundation of an enduring and comprehensive scientific instruments industry.

2. Mr. E. B. Rajdevkar, Bombay.
3. Mr. E. R. Gee, Calcutta.
4. Dr. S. K. K. Jatkar, Bangalore.
5. Dr. H. J. Taylor, Bombay.

VII. INDIA'S POSITION WITH REGARD TO HER SULPHUR RESOURCES.

(Sections of Chemistry and Geology.)

Dr. Raj Nath, Benares, presided.

1. Mr. E. R. Gee, Calcutta.

At the present time, India's industries demand annually some 30,000 to 35,000 tons of refined sulphur (brimstone). Of that amount, some 25,000 tons are converted into sulphuric acid for use in the various chemical, metallurgical and allied industries.

Sulphuric acid is relatively difficult and expensive to transport over long distances. As a result, factories capable of manufacturing this acid have sprung up in this country and, up to the present, these factories have remained absolutely dependent on raw-material—refined sulphur or brimstone—imported from distant, foreign countries. Before the present war, those countries included Italy, Japan and the U.S.A.

Thus, contrary to the more usual trend of events in India, we have a case of a manufacturing industry forging ahead of the production capacity of the indigenous, raw-material resources of the country, a position which may work satisfactorily in peace-time but which is so obviously a precarious one in times of war.

Before the present crisis had proceeded very far, it became imperative that India should, without delay, become self-supporting in sulphur otherwise a difficult situation was likely to arise in a number of her essential war industries. This possibility has increased very considerably during the past month as a result of the action of Japan.

Sulphur or sulphuric acid can be manufactured commercially in several ways:—by the roasting or processing of various metallic sulphides (of iron, copper, lead and zinc), by the reduction of gypsum and anhydrite (sulphates of calcium) and certain other sulphates; and from deposits of native sulphur occurring in nature in its elemental form.

Regarding the availability and utilization of the indigenous resources of these sulphur-bearing minerals, India, unfortunately, has not developed chemical industries for producing sulphur from the immense deposits of sulphates that are known to exist in various parts of the country. Regarding the utilization of the sulphide resources, at the close of the 1914–18 war, a scheme was approved for smelting 25,000 tons of Burmese zinc sulphide ore annually in this country. Had this scheme been put into execution, it would have yielded some 25,000 tons of sulphuric acid per year. Suggestions have also been put forward for the recovery and utilization of sulphur dioxide from the gases evolved during the processing of copper sulphide ores at the Indian Copper Corporation's plant in Bihar, also for the utilization of iron pyrites, of which certain occurrences have been proved in several parts of India.

As regards deposits of native sulphur, when war broke out the most promising known occurrence in India was that of Sanni, in Kalat State, Baluchistan, where limited exploratory work had, in 1919, indicated the likelihood of a minimum reserve of some 36,000 tons of sulphur-ore capable of yielding about 10,000 tons of refined sulphur. In addition, native sulphur was known to occur at several other places in Baluchistan including the extinct volcano of Koh-i-Sultan; also, in the volcanic islands—Barren Is. and Narcondam—of the Bay of Bengal, but we were either quite uncertain of the quantities available or they were thought to be trivial.

The necessity of remedying the position was fully realized by Government and was discussed at the early meetings of the Board of Scientific and Industrial Research, whose Director Sir S. S. Bhatnagar is, unfortunately, unable to be present here to address you to-day. The urgency of the problem had been apparent to the Geological Survey of India and a scheme of exploration was immediately submitted to Government by the Director of that Department—Dr. C. S. Fox. This scheme, which in Baluchistan was put into operation in November, 1940, was fortunate in producing very promising results within the following eight months, at the end of which period the Department were in a position to hand over for ready exploitation, reserves of high quality sulphur-ore which are considered, certainly sufficient to make India self-supporting for a period of two years and which will, in all probability, meet the requirements of her industries for a very appreciably longer period. Though occurring in a very distant part of the Indian Empire, the deposits in question are rich and extractable with relative ease and, particularly in view of the present high price of imported brimstone are likely to prove exploitable on an economic basis. Such, briefly, is the position to-day.

Regarding the geology of the Baluchistan sulphur deposits, a glance at the map shows the area to be divisible into four units:—

(1) In the east, filling the re-entrant formed by the hill ranges of central Baluchistan, are the alluvial sands, loams and clays of the plains stretching northwards and westwards from Jacobabad (just outside Baluchistan territory) to beyond Sibi and Gandava (in the district of Kachhi, Kalat State).

(2) North, west and south-west of this plain country, rocks ranging in age from Permian to Upper Tertiary form a wide belt of upland country constituting the core of the agency. With the exception of the Mesozoic serpentine intrusions of the Hindubagh area, with their important deposits of chromite, together with certain igneous rocks in Kalat and Las Bela States, these strata are sedimentary. Limestones, largely of Jurassic age, form the inner hills, capped in places by lower Tertiary limestones and shales. The latter comprise the outer—southern and eastern—ranges and are followed in the outermost ridges and in the angle of the re-entrant

towards Quetta by higher Tertiary sandstones, limestones, clays and conglomerates.

(3) West and south-west of this closely folded and strike faulted region, is the monotonous stretch of argillaceous and arenaceous deposits known as the Kojak Shales of Oligocene age together with the overlying, more recent clays, sandstones and conglomerates of the southern Mekran. The junction of this zone and the Upper Palaeozoic—Tertiary complex to the east is often complicated by faulting.

(4) Lastly, in the Chagai district of western Baluchistan lying west and north of the Kojak Shale zone, is a geological province including, amidst wide stretches of sandy desert, a number of exposures of volcanic rocks Among the latter, is the very recent volcanic suite of Koh-i-Sultan which is of primary importance in the present instance. This recent volcanic suite is represented westwards, a short distance across the border in Iranian territory by the volcanic mountain named Koh-i-Taftan (13,034 feet), known also to contain sulphur.

Deposits of native sulphur occur in each of these far geological provinces. All the occurrences are of interest from the point of view of the origin and formation of sulphur.

In the alluvium, a few miles within Baluchistan to the west-north-west of Jacobabad (Sind), an occurrence was investigated. The native sulphur, as fine grains, was found to occur sporadically in minor quantities associated with bands of fine-textured sand-rocks within a few feet of the surface. The sand-bed contained small quantities of sulphuretted hydrogen and, a few feet below, emanations of gas, lethâl in its reactions, were met with in one excavation. Unfortunately facilities were not available to analyse this gas. From its effect on the persons engaged in exploration, Dr. Fox has suggested that the gas was a mixture of carbon dioxide and methane, which would fit in with the chemical reactions involved in the reduction of sulphates—present in the alluvium—to native sulphur; methane (derived from included decaying vegetation) being one of the hydrocarbon gases concerned in the reduction process and carbon dioxide being the principal gaseous product.

In the case of the second geological province, comprising the hill ranges principally of Mesozoic and Tertiary age, many so-called 'sulphur-springs' are reported. The greater number of these consists of springs issuing from the limestones, the water of which contains recognizable quantities of hydrogen sulphide gas. From these gaseous emanations, native sulphur is often deposited in the near vicinity of the springs, but in all cases known so far, the quantities are small and of no present economic importance. At other places, bands of sulphur-bearing rock occur associated with gypsum and limestone, sometimes closely connected with seepages of oil, and it is suggested that the sulphur has originated by the reduction of the sulphates by the action of the petroleum hydrocarbons. Such instances occur in the Bolan Pass near Gokurt on the road from Sibi to Quetta.

Economically, the most promising instances of sulphur occurring in close association with petroliferous material is that of Sanni, Kalat State. There, the sulphur-bearing rock is a fairly hard sandstone, the sulphur occurring as fine grains impregnating the sandstone and also, in purer form, along cracks and joint-planes. The sandstone in question is probably of Nari (Oligocene) age and crops out in the foothills south-west of Sibi. Several distinct horizons have been proved containing from 25 to over 40% free sulphur and each several feet in thickness. The total probable quantity of sulphur available is yet unknown, but the results so far obtained warrant further exploration.

Regarding the origin of the sulphur at Sanni, certain geologists of Messrs. The Burmah Oil Co. Ltd., had previously suggested that it has been derived from a more deep-seated source of gas containing a high percentage of sulphur derivatives. This may well be the explanation. On the other hand, it appears reasonable to suggest that an explanation similar to that given in the case of many American and Silician deposits and the occurrences of the Bolan Pass area is attributable—namely, the reduction of sulphates (occurring in the sedimentary sequence) by hydrocarbon substances. The sandstones and clays of the sulphur-bearing Oligocene sequence at Sanni contain only very minor quantities of sulphates, but gypsum occurs in abundance in the lower Tertiary (Eocene) sediments of north-western India. It is suggested that during the course of their upward permeation, the hydrocarbon gases caused the reduction of these sulphates and that the liberated sulphur was carried upwards with the oil and gas and deposited in the joints, fissures and pores of the neighbouring cap-rock.

Within the upper Tertiaries of southern Baluchistan, minor occurrences of native sulphur are met with at several places in association with mud-volcanoes. One newly-reported occurrence of sulphur in the Mekran area was recently examined. It occurs in the alluvium which caps the Tertiary sediments near the coast west of Gwadar, not far from the Iranian border. The sulphur is met with as a band at or within a few feet of the surface. Further exploration is required to prove the extent of the deposit. It is possible that the sulphur may have originated from sulphur-bearing gases arising from the underlying Tertiary but it might equally well, perhaps more probably, have been derived by the interaction of hydrocarbons on sulphates occurring in the saline recent alluvial deposits that border the sea-coast.

Turning now to the fourth geological province—the desert region of the Chagai district of Western British Baluchistan; here the sulphur is undoubtedly one of the products of recent volcanic activity. In that region, sulphur was known to have been worked in the past on a small scale by the Afghans. Later investigations gave the impression that the quantities available were very small. Recent geological work has shown this to be incorrect. The sulphur-ore occurs as extensive thick outcrops passing, in places, beneath beds of volcanic ash. The occurrence, even at the present day, of emanations of sulphuretted hydrogen (H_2S) from certain of the outcrops of sulphur-ore and from associated acid volcanic strata, combined with the presence of free acid (SO_3) in certain of the samples of ore examined, suggests that the sulphur has been deposited as a result of chemical interaction between those two substances. The liberated sulphur was deposited in the pores of the acid rock of the several craters and also along the joints and fissures. It is in that form, ranging up to over 70% free sulphur, that we find it to-day. For certain industrial purposes, refining will unoubtedly be necessary. for the manufacture of sulphuric acid however, it is suggested that at least the better quality ore could be consumed in the raw state.

2. N. N. Chatterjee, Calcutta.

Introduction.

It is gratifying to note that a symposium has been arranged on the subject of India's Sulphur Position—a problem which has lately drawn keen attention of the Government and the industrialists of the country and it is hoped that both official and non-official experts would co-operate freely with the Science Congress Association and contribute suitable articles on various aspects of this problem facing India. It is only by full co-operation of the different workers in this line that the Sulphur Position of India can be clearly defined and this symposium if successfully conducted is expected to be of immense help to the enterprisers in the line of sulphuric acid manufacture. It is well known that sulphur and sulphur bearing minerals hold a very important place in the mineral wealth of a country and that these raw materials form a valuable source for the manufacture of heavy chemicals including sulphuric acid, fertilizers, insecticides, paper pulp, explosives, dyes, rubber and of other miscellaneous sulphur chemicals. It will be out of place here to go into details regarding the different uses of sulphur. Of these, however, the most important item is the manufacture of sulphuric acid which again is absolutely needed for many useful purposes and is the key to most chemical and many metallurgical industries. It is now definitely established that the industrial development of a country is measured by the rate of consumption of sulphuric acid.

Raw-materials for sulphuric acid manufacture.

The sulphur bearing materials include chiefly the following:—

(i) Native sulphur;
(ii) Pyrites;
(iii) Gypsum;
(iv) Smelter gases;
(v) High sulphur coal and petroleum.

Native sulphur.

Of all the raw-materials just mentioned native sulphur is found to be the best suited and the cheapest for the manufacture of sulphuric acid. A reference to the statistics will show that all sulphur used in India and Burma is imported from abroad and due to the abnormal conditions arising out of the present world wide war, India is experiencing great difficulty in the matter of getting her supply of sulphur. The attention of the Government and the private enterprisers has been diverted to solve this acute problem facing India. Native sulphur has already been reported to occur at Sanni, Koh-i-Sultan, Koh-i-Taftan, etc., in Baluchistan but details about the actual reserves are lacking. It appears that, by a careful and thorough search that has recently been started in different parts of Baluchistan by the Geological Survey of India, some fruitful results have been achieved in this direction. It is, therefore, highly desirable that the G.S.I. authorities should make a short statement to enlighten us on this subject so that the present position may be clearly understood. Deposits of native sulphur have also been reported from several parts of Barren Island and I think the geological formations of the two volcanic islands—Barren Island and Narcondam Island—situated in the Bay of Bengal should be carefully studied and systematic prospecting work carried out to see if sufficient sulphur deposit could be obtained there.

Pyrites.

Regarding the utilization of pyrites for the manufacture of sulphuric acid many important points should be considered. In the first place, the various objectionable impurities, such as selenium, arsenic, chlorine, etc., in the different pyrite deposits have to be tackled. The burners that are now in use in different factories in India for burning sulphur have to be modified to burn pyrites. It is however gratifying to note that some successful attempt has been made at a chemical factory at Agra to install suitable burners to burn pyrites for the manufacture of sulphuric acid. Then again the important question of handling and transport of huge quantity of inert matter (about half of the raw-material) need also careful consideration unless of course the sulphuric acid plant is located near the pyrite deposits. Regarding pyrites in India we are even now in the dark as to the actual reserves of the different deposits. Regarding the reserves of the Sone valley pyrite deposit of which we heard so much last year, no official report has however appeared giving an accurate information on the subject. The other pyrite deposits which are few in number occurring in different parts of India should also be carefully prospected for estimating their probable reserves.

The Tertiary beds, particularly the Nummulitic formation, occurring in different parts of India should also receive proper attention by the geologists, both official and private, to see if workable beds of pyrites could be found. Thin streaks of pyrites have already been discovered in many places in Assam and the Punjab. In short, it may be said that though at the present moment we know very little about the actual reserves of native sulphur or pyrite deposits occurring in different parts of India the work that has recently been started by the Government officers is expected to give more definite information on this subject. If necessary, more intensive search should be started by the relevant department.

Gypsum.

A reference to the article entitled 'Sulphur Position of India' by Sir S. S. Bhatnagar, Director, Board of Scientific and Industrial Research (vide *Current Science*, May, 1941) will show that the question of utilization of sulphur from gypsum and formation of cement at the same time has already received attention of the Board as well as of the Government. Some Indian firm appears to have taken keen interest in the matter. The question of cost of manufacturing sulphuric acid has to be carefully considered and I think some place in the Punjab would form the appropriate locality for erecting such a plant, as gypsum, coal, limestone, clay, etc., are available there. In this process the high sulphur coals of the Punjab will find suitable use and the sulphur present in such coals will contribute towards the manufacture of sulphuric acid.

Smelter Gases.

Large quantities of sulphuric acid are made in some countries from the sulphur dioxide of the smelter gases liberated in the roasting of lead, copper and zinc ores before the metals are extracted from them. The sulphur content of the lead ores smelted at Nam Tu in Burma and of the copper ores smelted at the Moubhandar works at Ghatsila are at present waste products. The Indian Copper Corporation at Ghatsila and the Burma Corporation at Nam Tu may be persuaded to go into the question and if some suitable adjustment in their works is possible the gases could be recovered so that the sulphur problem facing India may be solved to some extent.

Sulphur from Coal.

About the presence of sulphur in coal it may be said that the Gondwana coals formed under fresh water conditions contain only insignificant percentage of sulphur whereas the Tertiary coals formed under marine or brackish water conditions contain very high percentage of sulphur sometimes as much as 8 or 9%. A few words on the topic of recovery of sulphur from these high sulphur coals might be of some interest to the members. It is quite well known that the Punjab coals, Baluchistan coals and the Upper Assam coals contain high percentage of total sulphur. It has already been shown by the writer of this note that these coals contain some amount of pyrites and a good proportion of sulphur occurs in organic state of combination. This organic sulphur, however, cannot be eliminated by any mechanical process of washing (vide *Proc. Nat. Inst. Sc. Ind.*, Vol. 6, p. 523). When such coals are subjected to high temperature carbonization, a small fraction of the total sulphur is expelled as various sulphur compounds along with the volatile matter and the remaining portion of the sulphur is retained by the coke residue. The sulphur compounds thus eliminated in the gaseous state can be subjected to Thylox or any other suitable process for their recovery. It is fairly well known that many of the Upper Assam coals produce excellent high temperature coke but as the coke retains large amount of sulphur it cannot be used for high class smelting operations. But if the sulphur content could be reduced below the permissible limit the coke with negligible ash content would be considered to be of the highest quality available in India. It is thus clear that though by simple process of high temperature carbonization certain amount of sulphur can be recovered from the coal, the coke residue may not be of much use to the metallurgical industry thereby losing its real and inherent value. The writer of this note carried out a series of experiments with high sulphur coals of India (*vide* Coal Symposium, published by the National Institute of Sciences of India) and communicated a paper to the Indian Science Congress, Benares, 1941, in which he indicated certain processes by which the major portion of the total sulphur could be eliminated from the coal in gaseous state leaving behind only a small fraction of sulphur in the coke residue. The gaseous sulphur compounds may be recovered by Thylox or any other suitable process and the coke residue with permissible amount of sulphur will be a valuable by-product and will form an important raw material in high class metallurgical industry for smelting operations. Of these processes mention may be made of sodium chloride treatment of coal prior to high temperature carbonization or passing of hydrogen, producer gas, over the coke in the carbonization chamber. These processes in the laboratory gave satisfactory results in eliminating major portion of the total sulphur from the coal. In case of non-caking high sulphur coals the same treatment would drive off the sulphur compounds which in turn can be recovered. The non-caking residue with small amount of sulphur can very well be utilized in blending with high swelling caking coals prior to carbonization. The non-caking residue may be briquetted before being used for boilers, etc., or may be utilized for the manufacture of water gas or producer gas. The attention of the Coal Industry is therefore drawn to this aspect of the sulphur problem and sulphur recovery particularly with regard to the high sulphur Tertiary coals of India. Attention of the Board of Scientific and Industrial Research may be drawn to this and it is hoped that both the Coal Industry and the Board of Scientific and Industrial Research would take the initiative and would make arrangements to conduct a series of experiments on a semi-industrial scale to see how far the laboratory results would be faithfully reproduced. If such attempts meet with success and yield favourable results, many of the high sulphur Tertiary coals of India hitherto ignored will become very valuable and will perhaps rank as the best coals in India. The sulphur compounds eliminated from the coals when recovered by suitable chemical processes will surely add to the sulphur resources of the country thereby improving the sulphur position of India to some extent.

It may also be mentioned that a small fraction of the total sulphur can be extracted from the coal by leaching with organic solvents but it is extremely doubtful if such an extraction process by organic solvents would be successful on a commercial scale. It is also doubtful if the major portion of the sulphur can be recovered by such process which at the same time appears to be a very costly one. Moreover, after the extraction by organic solvents the coal residue loses its caking property—a fact already established by the writer of this note. It is thus clear that though small amounts of sulphur compounds may be recovered from the high sulphur and good caking coals by leaching with organic solvents the coal residue will be of no use for the manufacture of valuable metallurgical coke (*vide* article 'Sulphur Position of India' by Sir S. S. Bhatnagar in *Current Science,* May, 1941; and article 'Sulphur Position of India' by N. N. Chatterjee in *Current Science*, August, 1941).

Conclusion.

An attempt has been made in the foregoing lines to give some idea of the raw materials for the manufacture of sulphuric acid and the various lines in which the sulphur problem of India may be attacked for solution. If sufficient reserves of the raw materials in the shape of native sulphur and pyrites are proved then the question of following other costly processes for the recovery of sulphur may be put off. But in case the reserves of native sulphur and pyrites are found to be rather inadequate for India's domestic consumption it would be absolutely imperative on the part of the State to persuade the companies and other enterprisers to recover sulphur to the fullest extent or if necessary the State should commandeer the sulphur resources of the country and should devise ways and means to fully utilize the raw materials for the recovery of sulphur and sulphuric acid. In case India's position becomes critical for want of sulphur the question of higher cost for manufacture of sulphuric acid from gypsum, smelter gases or from high sulphur coals has to be solved and overcome for the industrial development, welfare and defence of the country. State control and intervention in times of difficulty and in case of emergency would thus appear to be imperative and in normal times State protection and help would also be necessary for the encouragement and proper development of the indigenous basic industries so that they might stand against unfair competition from abroad. Before concluding, to appreciate the situation the following quotation from Dr. Coggin Brown will be helpful—'Without cheap and abundant supplies of sulphuric acid, India will never attain the position which her wealth of raw mineral products gives her a right to anticipate, but in the metallic sulphide of Bawdwin and elsewhere there is a sulphur reserve available if and when it is required.'

3. L. S. Krishnamurthy *and* Syed Kazim, Hyderabad-Deccan.

The discussion on the above subject is confined to the occurrence of sulphur mostly in the form of pyrites in the Hyderabad State.

The ore is known to occur with (1) the auriferous Dharwars, (2) in the limestones of the Purana group, and (3) in the Gondwanas, in association with coal measures.

The first two occurrences appear to be only of academic interest as the mineral has not been found in workable quantities in these formations. The third, is probably capable of economic exploitation as pyrites occurs in a fairly good quantity. It is now being thrown away as waste from the coal mines. It would be necessary to separate the pyrites from the adhering coal by modern methods of concentration. In view of the importance of the manufacture of sulphuric acid as a basic chemical industry, every available source of sulphur needs careful examination to gauge its potentiality.

VIII. ESSENTIAL OILS.

(Section of Chemistry, in co-operation with the Indian Pharmaceutical Conference.)

Dr. M. Qureshi, Hyderabad-Deccan, presided.

1. Dr. M. S. Patel, Bombay.

It was expected that the opening remarks on this symposium would be made by a very competetive authority on the subject. As that authority has not been able to turn up, I have been called upon to do this task on a very short notice after my arrival at Baroda.

My only excuse to agree to open this symposium is due to the fact that I have been instrumental in the establishment of a small industry for the production of one essential oil. I would describe our own efforts towards the production and marketing of essential oils.

Production of essential oils is a very ancient industry of our country. In one of our text-books we were told that the discovery of the Otto Roses was made by Noor Jahan, when she found a drop of oil floating on water in one of the water reservoirs which was filled with roses to prepare water for the bath of the queen. But we find much earlier references to sweet smelling oils in our ancient sanskrit literature and also descriptions of the processes for their production.

It is generally thought that the use of perfumery and indirectly that of essential oils is a luxury. This is far from true. From time immemorial essential oils have played an important part in the life and trade of almost all the people of the world. Besides giving sweet smell and flavour, essential oils indirectly act as antiseptics and preservatives in many cases. Aromatic chemical substances and oils used in the flavouring of our foods act as preservatives. Without them it will not be possible to store for long time some of the delicacies and pickles which we relish so much. Cloves, Cinnamon, Cardamom, etc., contain essential oils. Some essential oils and their derivatives act as anthelmintic substances also.

The carbolic acid coefficient of some of the essential oils is very high. Citral, a constituent of lemon, orange, lime as well as lemon grass oil has a carbolic acid coefficient of 16, and those of thymol, menthol, eugenol and citronellol are 25, 19, 15 and 14 respectively. It can be safely said that there are very few essential oils whose active ingredients have less carbolic coefficient than that of phenol. It is, therefore, possible that 'actual benefit derived from the use of essential oils and flavours prepared from them is beyond our comprehension'. Nobody would like or think of applying a substance like phenol or cresols or preparations made from them to his face or body. Perfumes made from essential oils are, therefore, 'used freely apparently for the pleasure it gives' by their sweet smell, but indirectly they act as antiseptics without the knowledge of the user.

'Barber shops and other similar places would be subject to danger of contagion' if the barbers did not use articles containing essential oils, or active ingredients found in essential oils, in the preparations they use for application on the parts of the body of their customers, which come in direct contact with their hands or their instruments and appliances. 'The habit of kissing' so universal in the western countries 'would be more dangerous if it were not for the widespread use of mouth washes and mouth and tooth preparations containing powerful antiseptics like menthol, thymol, etc. which have 15 to 25 times the germicidal value of carbolic acid'.

The trade in essential oils and essential oil-bearing seeds of this country with foreign countries is of considerable value. The statistics given in the Sea Borne Trade of India are very incomplete and so, it is very difficult to find out what is the exact position regarding the essential oil and allied trade. I give some figures which show that our total import and export trade in essential oils and essential oil-bearing seeds amount to, on the average, during normal times to about Rs.6 million or sixty lakhs per year.

Average exports of essential oils per year for a period of five years, 1934–1939.

Name of the Oil.	*Quantity in gallons.*	*Value in Rs.*	*Value per gallon.*
Lemon Grass ..	90,384	9,18,226	10·1
Sandalwood	11,744	11,66,815	99·3
Gingergrass	130	4,326	33·2
Palmarosa	9,219	2,88,006	31·3
Citronella	2	14	7·0
Cinnamon	3	28	9·3
Other sorts	3,218	66,238	20·5
TOTAL ..	1,14,700	24,43,653	21·3

Average imports of essential oils per year for a period of five years. 1934–1939.

Name of the Oil.	*Quantity in gallons.*	*Value in Rs.*	*Value per gallon.*
Synthetic ..	18,236	7,03,945	38·6
Almond ..	167	3,140	18·8
Bergamot ..	752	38,462	51·1
Cajuputi ..	1,201	15,426	12·8
Camphor ..	7,878	18,709	2·3
Cloves ..	1,172	33,563	28·6
Eucalyptus ..	1,916	28,134	14·6
Lavender ..	1,288	89,244	69·3
Lemon ..	1,835	66,765	36·3
Otto Rose ..	21	4,239	201·8
Peppermint ..	1,987	72,364	36·4
Other Sorts ..	27,204	4,17,605	15·3
TOTAL	63,657	14,89,591	23·4

Average exports of essential oil seeds per year for a period of five years, 1934–1939.

Name of the Oil.	*Quantity in tons.*	*Value in Rs.*	*Value per ton.*
Ajama	115	34,511	300
Ajwan	42	8,309	197·8
Aniseed	65	10,427	160·4
Coriander	4,951	6,99,205	141·2
Cummin (other than black) ..	1,170	5,90,710	504·8
Cummin (black) ..	101	26,966	267
Fennel	740	2,00,247	270·6
Fenugreek	1,482	2,98,507	133·9
Sawa or Dill.. ..	555	90,114	162·3
Other sorts	570	2,75,456	483·2
TOTAL ..	9,791	22,34,452	230

The above figures do not show several other essential oils imported into and exported from this country in small quantities or packages.

There are four methods for the production of essential oils. The most important and the most widely used process is of course the steam distillation process. The others are the cold pressing process, solvent extraction process and the enfleurage process. The latter three processes are widely used in foreign countries, but are hardly known to have been practised to any appreciable extent in our country. The modification of the enfleurage process, however, is known to have been practised in this country from time immemorial.

Our essential oil production at present is mostly carried out either on a moderately small or very small scale by indigenous workers in all parts of our country by primitive and generally simple, but very inefficient methods. The only exception is the production of sandalwood oil in the Mysore State, in Bombay and at Kanauj. Until very recently scientists and technologists of this country did not try to help the indigenous producers of essential oils in this country and that is one of the reasons, why our essential oil industry is mostly in a very backward state. It is, therefore, essential that our efforts should be directed to help in all possible ways the indigenous producers and show them the ways and means of producing better essential oils by more efficient and economical methods.

Ours is a country of varied climatic conditions and soils too, and so it should not be impossible to introduce into this country the cultivation of most of the essential oil producing plants found on the surface of the earth. What is needed is a very serious effort in that direction by all concerned with the whole-hearted and full co-operation of chemists. biologists, agronomists, pharmacists, soil specialists, botanists, plant breeders, plant physiologists, entomologists, perfumers, dealers in essential oils and flavours and chemical engineers.

Serious efforts in the following directions have to be made to develop our essential oil industry and to put it on a very sound footing:—

(1) A comprehensive study of the essential oil bearing plants that grow and that could be grown in this country.
(2) A detailed study of the composition and the properties of the essential oils that could be produced in large quantities in this country.
(3) Improvement in the yield as well as in the quality of essential oils in the plants, seeds, roots, etc., by the application of results so far achieved in the modern scientific studies.
(4) A detailed study of the world markets for essential oils and their active components, derivatives and by-products, etc.

There are several obstacles in the development of our essential oil industry, but these could be overcome by patience and perseverance on the part of all concerned and also by political pressure. Some of the noteworthy difficulties in the way of the development of the essential oil industry of our country on a comprehensive scale are:—

(1) The countries that consume essential oils in very large quantities allow the imports of raw materials from which the essential oils are produced without any import duty while they charge a very heavy import duty on the essential oils as such.
(2) The demand in our country of some essential oils is so small that it is not possible to set up economic units for their production without having recourse to find a market for the same in foreign countries.
(3) The residues left after distillation do not find a ready market due to industrial backwardness of our country.
(4) Lack of initiative and a burning desire on the part of Government officials and other nation building agencies to develop the indigenous essential oil industry and thus enhance the wealth of the country.

It will be of interest to you to know that large quantities of cloves left after the extraction of clove oil from them are being imported into this country. The imported extracted cloves are used after the application of a suitable dye for adulterating genuine cloves imported into this country from Africa.

With regard to improving the yield and quality of essential oils, I give below a table which shows the percentage of oil in coriander seeds grown in different countries of the world:—

Name of the country.	*Per cent of oil in coriander seeds.*
India	0·15— 0·20
North Africa	0·25—0·35
Syria	0·26—0·34
Persia	0·25—0·35
France (Morocco)	0·25—0·35
Palestine	0·27—0·36
Asia Minor	0·30—0·40
Mexico	0·35—0·45

Name of the country.	*Per cent of oil in coriander seeds.*
Italy	0·50—0·60
Holland	0·50—0·60
Germany (Thuringia)	0·60—0·80
Moravia	0·65—0·90
Russia	0·75—1·20
Hungary	0·50—1·00

It will be noticed from the table that the yield of the oil from the Indian coriander seeds is about the lowest in the world. The same thing may apply to several other plants and seeds grown in our country. Here is an enormous field for the scientists connected with the development of agriculture in this country for exploration and experimentation.

During the last ten years with the help of my students and other collaborators I have tried to introduce in the Province of Bombay the production of some essential oils which were never produced in our country on a commerical scale before. We have succeeded in establishing on a sound footing the production of distilled lime oil. We have failed in our efforts to introduce the production of three oils. These oils are:—1. Peppermint oil, 2. Kavri (*Strobilanthes ciliatus*) oil, 3. Kilar (*Blumea erientha*) oil.

I will first tell you about our failures. During one of my wanderings I noticed some vendors of fruits and vegetables selling some bunches of a plant at Dahanu Road Railway Station, which they called peppermint. I bought a bunch and found that the plant did have a smell resembling the peppermint oil and that the leaves resembled to a considerable extent, the leaves of peppermint plants I had seen in some parts of the Michigan and New York States in U.S.A. The plant was grown by some big Irani horticulturists as a side line on a very small scale. I asked them whether they could grow for me about one-tenth of an acre of this plant if I paid them a fairly good compensation for their efforts. One of the horticulturists agreed, and so, we got busy establishing a small experimental distillery on the plantation. With the help of one of my students we produced two pounds of peppermint oil. As you all know peppermint oil is used in fairly large quantities in this country in the manufacture of a confectionery article known as extra strong or peppermint lozenges. I gave a sample of the oil produced by us to a confectionery manufacturer in Bombay. He produced extra strongs from the oil, supplied by me by the same process as he used in the production of the same material from the imported peppermint oils. The lozenges prepared from our oil had a slightly different flavour from those produced from the imported oils. On a further study of the problem we found that we might get better quality oil entirely satisfactory to the trade, if we distilled genuine peppermint plants. We, therefore, directed our efforts to obtaining peppermint plants from abroad which were yielding standard quality of peppermint oil.

While we were making necessary arrangements for the safe import of the plant, a very dear friend of mine who is an authority on pharmaceutical chemistry wrote to me that he had imported some rootlets of genuine peppermint plants from Germany. I encouraged him to cultivate them at two or more different localities. He raised a good crop of the plant and distilled several pounds of the oil from the plantation. We found that the menthol content of the oil was considerably low. We, therefore, found it almost impossible to find customers abroad for low menthol peppermint oil at that time. The yield of the oil calculated per acre of the crop was also fairly low. After a continuous work in growing the peppermint plant and distilling the oil for three years, we found that it would not be possible to produce peppermint oil on a large scale economically in the areas where we were experimenting.

We also found that the peppermint plant requires a particular climate and a particular soil and so, it could not be successfully cultivated wherever we liked. Unfortunately, we did not have at our disposal in this country the goodwill, co-operation and guidance of experienced and able agronomists and economic botanists. Besides, our field of activity could not at that time be extended beyond the Province of Bombay. We, therefore suspended our efforts for the time being. I, however, do feel that the plant would thrive considerably in some parts of Northern India and in some of the Himalayan tracts.

The oil from Kavri (*Strobilanthes ciliatus*) was found to be fairly valuable, but the trouble was that the plant grows wild in forest areas and flowers only once in three or four years. If we harvest the plants for the production of the oil, no seeds will fall to the ground from the plants and no new plants would grow in the next rainy season and so the plant would not be available for distillation in the next season. Unless some kind of arrangement is made, so that the plant will flower every year, by artificially broadcasting the seeds annually, and thus keeping a continuous supply of flowering plants every year in different patches of the various areas, it will not be possible to produce the oil regularly. Some such arrangement has to be made on an elaborate scale; otherwise no advantage could be taken of the abundant supply of kavri leaves available in the forests on the Western Ghats every three years in enormous quantities.

Kilar (*Blumea erientha*) is a weed which is found in all the fields, and fallow lands all over the country during the months of November, December, January and February. It gives a sweet smelling oil somewhat resembling crude camphor oil. The sweet smell of the plant has been utilized by the villagers in Gujarat in flavouring a food preparation called 'Undhia'. This preparation is made by roasting different kinds of beans and vegetables sealed in an earthen pot and then heating the inverted earthen pot placed on the ground by burning straw and bushes round about the pot. While sealing the pot, the villagers put in the earthen pot several bunches of kilar. The heat induces distillation of the oil from the plant which goes over to the beans and vegetables in the pot and imparts particular flavour to the preparation which is much relished by the villagers in all parts of central and southern Gujarat.

We produced several pounds of kilar oil and sent samples to some of the leading firms in Europe specializing in essential oils and also to the Imperial Institute, London. The oil was sent to these firms and to the Institute for determining its probable commercial value. We were informed that if the oil could be produced in large quantities, it might find a market and fetch a price of about three to four shillings a pound. It was, however, stated that unless there was a guarantee of a definite quantity of oil being supplied from year to year for many years, it will not be possible for anybody to take any interest or action in marketing this oil. It is natural that nobody would like to change formulae for his preparations and go in for the use of a new essential oil in place of well tried ingredients unless a constant supply is guaranteed. But neither we nor any of the government departments had the patience to undertake the pioneering work for the production of the oil from this weed.

I have described to you our efforts in which we failed. These failures, however, would show as to what should be done to change these failures into a success.

Now I will tell you about our efforts in which we have been thoroughly successful. In the month of July and August in certain parts of the Province of Bombay, there is an enormous production of limes. Sometimes the harvest is so big that the cultivators have to throw away several tons of limes on manure piles. The Department of Agriculture has tried to solve the problem by advising the owners of lime plantations to produce beverages from these limes and bottle them and supply them to hotels and restaurants. Their efforts in this direction have not been quite successful and so, my students and I tried to solve the problem of utilization of waste limes partially by the production of distilled lime oil.

During the first year of our efforts we produced about 1 lb. of the oil and tried to study its chemical composition and analytical constants. We found that the oil was somewhat inferior to the lime oil sold in European and American markets. The degree of inferiority was not so great, and so, we thought that if the oil could be produced commercially, it might find a market at a price—somewhat lower than the price of the West Indies distilled lime oil.

Next year we produced about 40 lb. of the oil and sent out samples of the oil to different importers and consumers of lime oil in England and Europe. Most of the replies we received from different firms were disappointing, and so, there was considerable uneasiness regarding our efforts in some responsible circles. We were, however, confident that a market ought to be found for the product, as the lime oil produced by us was far superior to the lemon oil produced in large quantities in Italy. We also felt that if the lime oil produced by us would fetch only as much price as that fetched by the Italian lemon oil, the party producing lime oil in India during the months of July and August would certainly realize more for his limes by distilling the oil from them than by selling limes or by throwing them away on manure pile. We, therefore, continued our efforts.

One day I received a cable from a well-known firm in Holland asking me as to the price at which I would be able to supply about 400 lbs. of the oil of the same quality as the sample which I had sent to them. I looked up the latest trade journals and found that West Indies distilled lime oil was sold at about 20 shillings per lb. I cabled them back and told them that I would supply the oil at 17½ shillings. I got the reply by cable that they could buy 400 lbs. of the oil at that price. We had no oil, and so, I told the firm that I would be able to supply the oil after about 4 or 5 months when the new crop of limes would be available. The firm agreed to my suggestion. Immediately after this we designed and got constructed by a local coppersmith a tin-lined still using a closed steam coil and capable of taking a charge of about 800 lbs. of minced limes at a time and put it into operation on the plantation.

It is one thing to produce the oil on a small scale or in a laboratory and quite another to produce the oil on a large scale, and so, I had my doubts whether the oil which we would produce on a large scale for supplying this 400 lbs. lot would be identical to the sample that I had sent to the firm which was produced on a small scale during the previous season. As soon as we had 400 lbs. of the oil produced, we got it filled in a specially prepared tinlined brass drum with a lid which could be locked and sealed and with a cock at the bottom which also could be locked and sealed. After filling the oil in the drum, I requested the Dutch Consul to come to my office and draw samples of the oil in duplicate from the drum and seal the drum and the samples with his seals. I also requested him to send one of the sealed samples by air-mail at our cost to the firm who had promised to buy 400 lbs. of the oil from us at the rate of 17½ shillings per lb.

I expected that some kind of difficulty might arise and so, I was not at all surprised when I got a cable from the firm stating that the sample of the oil sent by the Consul was not according to the sample that was sent by us six months ago, and so, they would not buy this particular lot of the oil. I sent them a cable asking them as to what price they would offer for the present lot of 400 lbs. of the oil, the sample of which was sent to them by the Consul. I got the cable stating that they would buy the entire lot of 400 lbs. at the rate of 16 shillings per lb. We agreed and immediately filled the oil from the sealed drum into tins and shipped the lot. Since then the Dutch firm and several German, British and American firms have become customers of this oil.

Thus the production for the first time on commercial scale of distilled lime oil in this country was initiated and put on sound footing within about three years from the day on which we had started work on the problem. This small industry is operating successfully for the last four years and has given employment to several persons in the villages where it is operating. We have published a detailed account of our work in connection with lime oil in bulletin No. 11 of the Department of Industries, Bombay, entitled. 'The production of lime oil and calcium citrate in the province of Bombay.'

At present there are three plants that are producing lime oil in this country. Due to war conditions the oil has found a market in this country and it is reported that the entire output of the oil is at present consumed here at about Rs.18 per lb.

It will be of interest to some of you to know that we have recently installed a super centrifuge operating at 15,000 R.M.P. for the extraction of essential oils from the juice of citrus fruits. This is the first instance in our country where a super centrifuge is used for the production of essential oils. With the development of citrus and allied industries, this important appliance will find a considerable use in the production of essential oils here.

I have given these details of our failures and our success to show some of the difficulties and problems that have to be encountered and solved with regard to the development of the essential oil industry in this country.

2. Dr. C. B. Shah, Baroda.

The subject has been discussed from (1) the Pharmaceutical, and (2) the Perfumer's and Cosmetician's points of views. The state of dependence on Essential Oils in India, the country which is the traditional Home of Spices and noted in the past for very high class of Oriental Perfumery and Cosmetic articles is deplorable. Organized efforts on the part of Scientists, Industrialists and the State are necessary to bring about the steady growth and development of this industry in the country. A few Essential Oils, as Oil of Rose grass, Oil of Lime, Oil of Eucalyptus, Oil of Sandalwood, Oil of Turpentine, etc., are at present manufactured in the country on a small scale, but looking at the abundance of raw materials available in the country and her agricultural productive potentialities, it is from economical as well as all other points of views desirable that serious thought should be given to establish Essential Oil Industry in the country on proper lines.

Considering Pharmaceutical needs of India in Essential Oils the British Pharmacopoeia has 18 and the United States Pharmacopoeia has 21 items in Essential Oils. Out of these, 13 oils—Oil Anisi, Oil Caryophylli, Oil Cinnamoni, Oil Coriander, Oil Eucalyptus, Oil Juniper, Oil Lavendar, Oil Lemon, Oil Mentha Piperata, Oil Nutmeg, Oil Rosemarini, Oil Sandalwood, and Oil Turpentine are common to both the Pharmacopoeias although in some cases with different specifications of standards. The remaining five oils which are in the British Pharmacopoeia but not in the United States Pharmacopoeia are—Oil Aibetic, Oil Anethi, Oil Cajuputi, Oil Caraway and Oil of Australian Sandalwood. The 8 oils which are in the United States Pharmacopoeia but not in the B.P. are—Oil Auranti, Oil Fennel, Oil Mentha Viridis, Oil Pine needle, Oil Rose, Oil Sassafras and Oil Sinapis volatile.

Considering the resources of India it is quite possible for her to manufacture most of her requirements in Pharmacopoeial Essential Oils, provided proper consideration is given to the difficulties that come in the way of successful undertaking and development. The main difficulties are the imposing of foreign Pharmacopoeial standards on Indian products. Constituents of Essential Oils generally depend upon the quality of raw materials, and the quality of agricultural raw materials depends upon the climatic and soil conditions of the country. Therefore the standards for Essential Oils for India should be based on the average quality of oils that can be obtained from Indian indigenous sources. For example, Eucalyptus Oil produced in India does not contain 70% Cineole as specified for Eucalyptus Oil in the B.P., and this being the Pharmacopoeial Oil, and the B.P. being at present the legal document for judgment, if the Indian quality is enforced, it would be considered below standard, and the Eucalyptus Oil as produced in India cannot be dispensed or sold for medicinal use and therefore the indigenous manufacture of this oil will gradually cease if steps are not taken in time to modify the official specifications of standards so as to be suitable for Indian Eucalyptus Oil. This is just an example and the same may be the case for several other indigenous oils that can be locally produced.

From the standards for various Essential Oils set up in the B.P., it appears that the B.P. has given protective considerations to English Lavendar Oil and the Australian Sandalwood Oil by giving different specifications of standards for the English and the Foreign Lavendar Oils, and also setting up a separate monogram for the Australian Sandalwood Oil, thus helping to promote the English Lavendar Oil and the Australian Sandalwood Oil industries. Special attempts, therefore, ought to be made if Indian Essential Oil industry is to be stimulated and developed, to determine and arrive at definite specifications of standards that can be reasonably applied in India in conformity with the quality of Essential Oils that can be produced from the Indian indigenous sources, and the State should further formulate necessary protective measures, if need be, to safeguard the Indian manufacture of Essential Oils from undesirable foreign competition.

Essential Oils are also consumed in large quantities for Perfumery and Cosmetic uses, and it is now high time that India should revive her Art of Perfumery and Cosmetics on modern lines. The large consumption of Essential Oils in various synthetic perfumery and cosmetic articles will not only enlarge the scope of the Essential Oil Industry but will also save the country from drainage to other countries of a very substantial amount of money. Further, the developing Soap Industry of the country will not be independent or self-contained unless it will be able to obtain the necessary perfumery articles produced within the country. In order to develop the technical art of Perfumery and Cosmetics on modern scientific lines it is necessary that technical Colleges and Universities in India should institute where possible graduate and post-graduate optional courses in these subjects.

3. Dr. J. N. Ray, New Delhi.

4. Dr. J. L. Sarin, Lahore.

IX. MINERAL POLICY FOR INDIA.

(Sections of Geology, and Geography and Geodesy.)

Mr. D. N. Wadia was in the chair and when he left Dr. Raj Nath, Benares, presided.

1. Dr. J. A. Dunn, Calcutta.

At last year's Science Congress we had a discussion on the utilization of India's mineral resources. Much of what was discussed at that meeting comprised suggestions on future mineral policy. At the meeting it was also decided that a resolution embracing the views expressed should be prepared by a sub-committee, and submitted to Government. But the sub-committee never actually functioned.

It may be of interest to recapitulate briefly some of the points which I outlined at the Benares meeting:—

(1) India's mineral industry is not backward and has not lagged far behind the markets' capacity to absorb production.

(2) Mineral rights should preferably be vested in Government.

(3) Rents and royalties should be at such rates as will provide Government with the maximum return for the depletion of the country's wasting assets, but yet will not bear unduly heavily on the miner.

(4) Mining leases should be allotted preferentially:—

(*a*) To those who will treat the minerals in India.

(*b*) To those with considerable capital who can work the deposits efficiently.

(*c*) Certain deposits should never be mined, such as float iron-ores which, in working, occasion greater damage to forests than the value of the deposits is worth.

(*d*) Certain rather rare deposits should be withheld from mining for a while until related industries, when developed, make them usable in India.

(5) The domestic treatment of mineral raw-materials should be encouraged as far as possible. In some minerals, like mica, ilmenite, and manganese, there is never likely to be a large domestic market and we must export. Resources of iron-ore are so vast that export is always advisable. Mineral development depends on cheap power.

(6) Prospecting might be stimulated by offering a small bonus to villagers for new finds.

(7) Research on the industrial development of a long series of minerals was suggested.

(8) Statistics of mineral production should be more complete.

(9) A bureau of mineral information should be established.

(10) There should be closer co-operation between Government, industrial, and University geologists.

One could keep on adding to this list of the means by which India's mineral resources might be developed to the best advantage. A Government Experimental Station for investigation of the treatment of minerals would, of course, be useful. From time to time one meets with instances of small producers being unable to market their material, or of small consumers being unable to obtain materials which are available in the country; some co-operative form of marketing may be useful, such as the Mineral and Metal Exchanges in some countries. Yet again, I have noted instances of small miners with good properties who have found it difficult to secure sufficient capital to work their mines efficiently.

All these are problems in which the Geological Survey of India is now and always has been vitally interested. There are, however, those who, with little knowledge and less experience of our work imagine that the Geological Survey is merely concerned with the purely scientific viewpoint of geology in India. A little reading of our publication or a day spent in our laboratories, would cure that misapprehension.

I would also emphasize that the Geological Survey's vast detailed knowledge of India's minerals has been accumulated during the steady continuous mapping which has been in progress throughout the last century. There are many people who are under the impression that minerals can be garnered like apples in an orchard, that it is a simple matter to search for workable deposits, and that during war time it is only necessary to send out the geologist and he will produce the minerals. But India is a vast territory, much of it is geologically little known, geologists are few and they cannot just go out helter-skelter over the countryside looking for minerals haphazardly. The detailed steady mapping of many years of peace has supplied records of certain mineral deposits which in normal times could not be economically worked, but which in times of stress are available. Hence, increasingly detailed geological mapping must always remain the foundation of geological work in India—I would be sorry for India, should this fact even be forgotten or ignored.

The above are matters in which India and the provinces are concerned individually. There is however, a wider aspect—the significance of a country's mineral to the world as a whole.

During the past year the outlook of people throughout the free world has shown the beginnings of a change which is almost revolutionary in character—there is a marked tendency to think internationally rather than nationally. The Roosevelt-Churchill Atlantic Charter recognized as one of its points the desirability of a more free availability of raw materials amongst nations.

It seems to me almost futile to discuss, at present, details of possible post-war policy and particularly of mineral raw materials. One may hope that nations will consent to frame an international policy for the co-ordinated and rational utilization of mineral resources throughout the world.

India's mineral resources in recent years have shown an increased tendency to be placed on a provincial basis rather than on the past national basis. If this country is to take its place amongst the nations of the world, it will be necessary to conform to whatever general scheme of international mineral policy that may emerge. We must learn to think here, as elsewhere, neither provincially, nor nationally, but to regard ourselves as the trustees for the world of those minerals within our territory which the world in general needs.

At the moment such considerations may appear altruistic, but their intensely practical significance may be appreciated when we remember that the next 100 to 200 years will witness a vast diminution in the mineral resources available throughout the world.

Personally, I feel that the time for detailed discussion of future international mineral policy, and of how India will be effected, is not yet, but we must await the emergence of the post-war international political framework.

2. Mr. E. R. Gee, Calcutta.

The majority would agree that measures aiming at amalgamation and conservation, judiciously applied, are necessary in the case of many of the mineral resources of India. The first step towards t[illegible] the acquisition of the more important minerals by the State, as has been done in the case of coal in Great Britain and in the case of all minerals in certain other countries. Combined with this is the necessity of imposing, in certain instances, stricter measures of exploitation in order that, from the various deposits, a maximum percentage of their total reserves can be rendered available to the manufacturing community. Government assistance, in the form of official and State-aided bodies with the object of furthering research in fuel and mineral problems and in allied industrial questions is, of course, equally desirable. The above mentioned measures do not entail nationalization, they merely anticipate a greater measure of Government control, guidance and assistance.

To extend the policy of conservation to limiting the export of many of India's minerals, as some people advocate, is, I consider, unsound; except perhaps in extremely rare cases of proved immediate national necessity.

What would have happened in the past had such a policy of strict conservation been followed in the case of other important countries of the world? What would America, Russia, Rumania, Iran the East Indies and Burma have lost financially and from the point of view of employment had they decided to conserve their own oil resources for internal use only? Similar remarks apply to coal in the case of Great Britain, France, Germany, Poland, etc., and to Germany in the case of potash salts and in Chile in the case of nitrates, numerous other examples could be cited.

Again, are we to conclude that all minerals of high value to-day will necessarily remain essential to industry in the future? Is it not probable that, following the present period of intense scientific research which is being advanced increasingly during the present crisis, the conception of what is an essential mineral will be seriously changed? Would those who advocate the restriction of export of much of India's mineral wealth, advise the total conservation of her mica resources, from which industry India stands to gain financially to a very appreciable extent? For it is not improbable that an artificial substitute for mica will be forthcoming in much the same way as substitute processes for the manufacture of rubber, sulphur, cryolite, artificial manures, etc., have been developed. Also, it appears not improbable that, in the not-distant future, power alcohol and synthetic oils will be successful competitors with oil-field products. With such advances in industrial science, and with the rapid development of the numerous varieties of plastics and synthetic resins, it seems likely that present ideas regarding the relative values of particular minerals will have to be revised before many years have passed.

Another aspect of the problem might be mentioned. Those in India, who advocate the building up of an important maritime trade using ships constructed in Indian ship-yards might legitimately expect that a large proportion of that trade should be utilized in meeting the demand of India's mineral products in overseas markets and in bringing back to India other products essential to the country's industries and not available in this country. Any such shipping enterprise would be handicapped considerably were strict measures of mineral conservation enforced.

Therefore, except in certain rare cases, I regard mineral conservation—that is to say, the prohibition by the State of the exploitation and export of minerals—as a short-sighted policy.

To my mind, the factor which appears to be most damaging to the economic development of the mineral and allied industries of this country, both for internal consumption and for export, is the high cost of transport of raw materials from one place to another within the country itself. Distances in India are usually great, the raw materials (ores, including fuel) are usually, in proportion, much heavier than the finished manufactured product and they have to be collected and brought to the factory. As a result, many articles which could be produced in India would under present conditions, be too expensive to attract the would-be purchaser in this country; the finished products—much lighter in weight than the ores and fuel from which they are manufactured—can be brought more cheaply by sea transport from those foreign countries where the cost of internal transport of the initial raw materials is relatively small.

Therefore, for the successful development of India's mineral industries, I consider it essential to have relatively cheap rates of internal transport in the case of ores and fuels. As above-mentioned, India's resources are scattered and for the purpose of manufacturing the majority of finished articles, it is necessary to convey large quantities of heavy and often bulky ore and fuel over great distances. Were this initial disadvantage of high internal transport costs removed, there is no doubt that it would give a great impetus to the development of India's mineral and allied industries. Such a measure would in all probability render unnecessary the imposition of tariffs, bounties, subsidies, etc., and would incidentally, tend towards greater conservation as it would allow in some instances the profitable extraction and treatment of deposits of poorer quality.

The mineral policy here advocated is therefore:—

(i) The acquisition of the mineral resources by the State, exploitation being left in most instances to firms and individuals.

(ii) Limited State control over exploitation to ensure efficient working, a high standard of labour conditions and prevention of waste.

(iii) Advice and assistance by the State, by the financing and encouragement of mineral and industrial research.

(iv) Cheap internal freight charges in the case of ores and fuels.

Given these four, it is suggested that industrial enterprise by private firms and individuals in India is capable of looking after itself, of obtaining the economic maximum out of the country's mineral resources and of competing successfully with foreign opposition.

3. Mr. N. N. Chatterjee, Calcutta.

Introduction.

The President of the Geology Section has invited discussion on a very important subject like the above at a time when the country's Government as well as the general public are taking sufficient interest in the cause of industrial development of the country.

National Mineral Policy.

Last year at the Benares Session of Indian Science Congress there was a symposium on 'Utilization of India's mineral resources' and in the discussion I suggested that in order to initiate and encourage proper and healthy development of mineral resources of this country India should have a *National Mineral Policy* and that there should be a central organization like the National Research Council of other countries. The Government has recently started a Board of Scientific and Industrial Research as a war-time measure to encourage development of industries in this country. It is suggested that this war-time industrial measure of the Government should ultimately be made permanent and should be based on a National Mineral Policy.

In order to discuss the proper functions of a National Mineral Policy for India, I think the following suggestions deserve careful consideration.

Reserves of Mineral Wealth.

(1) To procure more definite information regarding the actual reserves of the different mineral deposits of the country.

In order to collect all possible data on this subject I think the present staff of the Geological Survey of India would seem to be inadequate and the Government may be moved to expand the department accordingly. The Provincial Governments should also take adequate measure to carry out proper mineral survey work.

Conservation of Mineral Wealth.

(2) To devise ways and means for conservation of the mineral properties—the national asset of the country.

Maximum Extraction of Minerals.

To explain clearly it may be said that the process of conservation includes two important aspects, namely, maximum extraction and proper and efficient utilization of the economic minerals. It must be admitted on all hands that the methods that are prevalent nowadays in extracting coal, mica and other important economic minerals are nothing but wasteful processes and quite recently some attempt has been made by the Indian Government to introduce sand-stowing in coal mines for maximum extraction and safety. But a careful scrutiny of the affairs would show that by this measure the problem could not be properly solved. It now seems necessary in the interest of conservation of the national wealth of the country that more precautionary measures should be taken in this respect. Similar attempts should be made with regard to mica, iron, manganese and other economic minerals so that maximum extraction may be carried out in practice.

Proper utilization of minerals.

Regarding utilization it may be said that the underlying principle for proper utilization should always be to take the country's welfare and total ore-reserve into account. The efficient uses of minerals should be guided according to modern knowledge of ore-dressing, concentration and metallurgy. These factors should form the foundation and structure on which the industries should grow and flourish. Simple production and consumption of minerals may not mean that proper utilization has been effected. Sufficient importance should therefore be laid on the limited mineral reserves of the country and on their proper utilization.

Present unhealthy condition in India, re : extraction and utilization.

To effect proper and efficient utilization the various physical and chemical characters of coal and other economic minerals should be definitely known. It may be pointed out that even at the present day the conditions have not been very favourable and healthy with respect to proper utilization of minerals. For example, coal which was discovered in 1774 is not properly utilized even now and the malpractices have often been criticized and condemned but with very little effect. Other examples may be cited.

Board of Scientific and Industrial Research.

In order to initiate series of investigations on coal and other minerals the Board of Scientific and Industrial Research recently started by the Indian Government should organize research and distribute work and supervise progress of work and should recommend the various uses to which the different types of minerals and coal should be efficiently put. The methods of purification, concentration and preparation for the market should also be definitely stated by this Board. The different specifications for various uses to be evolved and standardized by this Board. These data and information should be made available to the public in cheap pamphlets so that the people may be properly educated in this line. If the U.S.A. and U.S.S.R. can bring out frequent publications (economic bulletins) at a cheap price, it is not difficult to assume that the India Government will be able to publish even cheaper bulletins as the labour is so cheap in India. In order to carry out their functions properly there should be under this Central Board of Scientific and Industrial Research two separate research stations to be directly under respective expert bodies, namely:—

(i) Fuel Research Board, and
(ii) Mineral Research Board.

Constitution of Fuel Research and Mineral Research Boards.

It may be suggested in connection with the constitution of these Boards that besides Government officials, few non-official experts with sufficient experience should be co-opted.

Fuel Research Board.

The Fuel Research Station should be immediately started and located at the Alipur Test House where necessary equipment and staff are already existing and further expansion may be made at a moderate cost. In this laboratory various properties of different types of coal and methods for their improvement, etc. should be conducted and the proper ways for their utilization should be indicated. Series of experiments should be carried out on semi-industrial scale to see how far the laboratory results hold good in practice.

Mineral Research Board.

The Mineral Research Station should be allowed to develop in the Geological Survey of India laboratory and the important properties of the ore and gangue minerals and the nature of the associated rocks should be studied in each and individual case. Experiments should be conducted in each case to improve the ore minerals by methods of concentration, washing and removing the impurities. This information when published will go a long way in helping the enterprisers in the respective lines. The section of Mineral Research Station when fully developed will continue to render very useful service to the country in the lines of the U.S. Bureau of Mines. The G.S.I. department would require adequate expansion to tackle these problems efficiently.

State control necessary.

From what has been said and discussed, under the circumstances the primary duty of the Government should be to follow the National Mineral Policy in the matter of proper and efficient utilization of the economic minerals. It would thus appear that in the interest of conservation the Government in future should discourage malpractices of utilization and stop wastages of minerals and will have power to intervene in such cases and stop them by strict legislation. In this connection I may quote here what Mr. Treharne Rees wrote as far back as 1920 (*vide* Coalfields Committee Report, 1920):—

'Coal is a national asset on which the manufacturing industries and commercial expansion of the country depends. A land owner or colliery proprietor is at present in a position to waste this national asset without restriction. By such waste he may obtain immediate financial benefit, but he injures the country, damages his property and diminishes the estate of his heirs; we hold that the State has the right in the interests of the community to step in and prevent the dissipation of the country's resources.'

The export of raw materials should be condemned and discouraged wherever possible. It is really unfortunate that the condition has remained the same even now in 1942.

Government protection to Mineral Industries essential.

(3) To give impetus to the enterprisers to start suitable industries in India based on mineral wealth, and if necessary the domestic industries should receive State help and protection to stand against unfair competition from abroad.

Due to prevailing war conditions and due to abnormal fall in imported goods many of us expected that several industries would start immediately and flourish in order to supply the needs of the country but India is experiencing great difficulty on account of her lacking in many things including various chemicals, machinery parts, alloys, etc. On careful scrutiny of the intricate problems relating to the growth of fresh industries in these lines it has been found that they cannot be successful unless some sort of Government help and protection is assured to allow them to thrive in spite of foreign competition at normal peace time.

It is certain that on account of abnormal and difficult circumstances due to war the India Government has followed the war-time Industrial Policy and has declared that those industries that are contributing towards

'War Effort' would receive encouragement and protection even during the peace-time after the war. I may quote here the following lines from the speech of the Commerce Member of the India Government delivered at Calcutta at a meeting of the Committee of the Bengal National Chamber of Commerce: 'The Government of India cannot divest themselves of their responsibility towards industries that would be brought into existence to meet genuine war requirements and civilian needs, and they would protect these industries after the war is over from unfair competition from abroad'. It is therefore hoped that this war-time industrial policy of the Government should ultimately be a well-considered, comprehensive and permanent measure and should be based on National Mineral Policy.

Central Marketing Board.

(4) To form a Central Marketing Board for the benefit of the Indian industries and trade.

There should be a serious attempt to start one well-planned and permanent *Central Marketing Board*. The proper specifications should be evolved and recommended by this Board which should be in constant touch with the Board of Scientific and Industrial Research and should get the sympathy and support of the Central Government for the cause of systematic mineral development and greater expansion of mineral trade of the country.

Indian Mines Act re. regulations for Prospecting Licences and Mining Leases should be revised.

(5) The rules and regulations governing grant of Prospecting Licences and Mining Leases to the companies or individuals in different parts of British India and Indian Native States should be carefully compared and scrutinized and they should be placed on more rational and uniform basis than what are prevalent to-day.

The question of fixing royalty rates of the different mineral properties should also be discussed and the rate and scale of fees should be placed on fair and equitable basis. There should not be any difference in the royalty fees at two neighbouring places whether located in British India or in an adjoining Native State when the same mineral deposit with similar properties and conditions run through them. The geology knows no political boundary and the same mineral vein having more or less the same conditions of location and transport facilities may run through different Provinces and States. If the conditions are different, there should correspondingly be some variation in the scale of royalty. Due to present-day autonomous Provincial Governments the position has become worse and I think the question should once again receive due consideration of the India Government and the members of the central legislature. Like the Mines Act, the regulations regarding grant of Prospecting Licences and Mining Leases of mineral properties should be in charge of the Central Government so that the rules can be applicable equally to all the places in India. The properties lying in the Native States should also be guided by almost similar regulations and the authorities of the Native States should therefore be persuaded to adopt this measure to avoid confusion and irregularity in the Mineral Business. This step, if successfully followed, will surely lead to a healthy and fair competition amongst the enterprisers engaged in the line of mineral industry at different parts of this country.

Purely academic discussions not helpful.

We are having to-day scientific and academic discussions bearing on a subject of great national importance. I do not know if this sort of discussion restricted only amongst the geologists and within the scientific circle would be able to produce the desired effect and bring about any fruitful result. I wish the representatives of the Central Government in charge of Commerce and Industry and some responsible members of Legislative Assembly were specially invited to attend this meeting and were present here to-day to listen to the debate and on our part we should have tried our best to bring home to them the fundamental issues of the problem facing India and I am quite confident that after the symposium is concluded they would easily understand India's real position in the field of mineral development and proper utilization. I hope they would also feel the urgent necessity of following a National Mineral Policy by taking immediate steps to safeguard the interests of India's mineral resources which are very limited in many cases and to stop the wasteful methods of extraction and utilization in case of high grade coals and other important economic minerals.

Concluding appeal to Government for immediate action.

In conclusion a very sincere and fervent appeal is therefore made to the India Government to give this discussion a careful consideration and it is hoped that after due deliberation they would chalk out in the very near future a suitable and favourable Mineral Policy for India with a far-reaching character. It is also hoped that they would have a sympathetic attitude towards the mineral industries in general and would guide them in the matter of maximum extraction and proper utilization of economic minerals. State control and intervention would sometimes be necessary for the achievement of the desired end. Successful functioning of this scheme will surely lead to proper conservation of the mineral wealth of the country and will do immense good to the people and to the generations yet unborn.

4. DR. V. S. DUBEY, Benares.

Introduction.

The list of goods imported to India shows that more than 50% of them are goods manufactured out of mineral raw materials. All the key industries of the nation depend upon the mineral raw materials. For the purpose of defence these metals and mineral raw materials are absolutely essential as without them we cannot have armament, ammunition and fuels. Though in the total national production the amount of metals and other mineral raw materials may not be high, it is of vital importance to the nation. Till now much attention has not been paid towards the development of our mineral resources, nor any policy laid out and whatever has been done is mostly due to foreigners. The production of the mineral wealth in India is controlled mostly by the foreign companies which exclusively own deposits like those of petroleum, gold, copper, etc. Whatever may have been done in the past, we have to see that in future there should be a vigorous development of our mineral resources by our own efforts for the interest of the nation. The Government has also not been much benefited directly by the mineral development. For example, a province like Bihar which produces mineral wealth worth about 12 crores of rupees did not get any appreciable revenue nor spent any money on the supervision, conservation and development of its mineral deposits. The agricultural and forest products though they are renewed every year, have paid a much higher taxation than minerals which are irreplenishable assets. The total revenue to all the provinces from the mineral production will not amount to more than a few lakhs of rupees at the most. Though there is a department under the Central Government called the Geological Survey of India to look after the mineral wealth, its aims have been more scientific than economic. It has been mostly an advisory body having no executive authority and the interest of the foreign Central Government has been more in its mind than the interest of the nation. The result of 80 years of working is that most of the minerals discovered have passed into the hands of the foreigners.

With proper development these minerals can make the country self-sufficient for self-defence, can supply raw materials for the development of heavy industries like the electrical, mechanical and chemical ones, and can be a good source of revenue to the provinces.

In framing the mineral policy the following points should be considered:—

(1) The stoppage of the export of key minerals and ores such as those of manganese, chromite, sillimanite and some other minerals.

(2) Local manufacture of metals and products now imported from abroad, from Indian mineral raw materials, such as aluminium, some light alloy metals, heavy machinery, heavy chemicals, mica goods, etc.

(3) Organization of agencies for bringing about the above-mentioned developments.

(4) The framing of a tariff policy on mineral export and import.

(5) The question of mineral taxation.

(6) The question of mineral conservation.

(7) The question of starting and developing mineral industries with the idea of industrial development and self-sufficiency for national defence.

I. *Organization of State Agencies for Mineral Development.*

All provinces and States should start mineral departments whose duty it should be to make a vigorous investigation of the mineral resources of each province or State in detail, which should be planned on a ten years' basis. The department should look after every kind of work in connection with mineral development.

A central mineral research council should be created and it should be composed of all the representatives of the different provinces and States, and non-officials, etc. on the lines of the existing Agricultural Research Council.

A central research institute should be started which should be financed by the different provinces and States.

Till such time as a central mineral research council for the whole of India is created, a provisionary advisory board composed of the above-named representatives should be set up. The functions of this board should be to offer free technical help, advice and information to provincial governments, States, companies and private concerns and to deal with any other matter connected with mineral development.

II. *Industries for National Defence.*

The materials required for national defence are fuel (mostly petrol), armaments, munitions, explosives, etc. The country should be made self-sufficient as far as petrol and other fuels are concerned. For this purpose synthetic petrol industry should be developed. We are in a favourable position for the manufacture of aeroplanes as we have got vast resources of aluminium, magnesium, beryllium. We have got almost all the minerals required for armament industry. Coal distillation industry which can supply a lot of peace time needs like synthetic fertilizers, can supply a number of chemicals needed in war. But none of these are developed as yet and should be immediately taken in hand.

It is very difficult to make much distinction between the requirements of war and peace time. Hence the industry should be so organized that it may be possible to shift immediately, when necessity arises, from peace to war requirements.

III. Technical Education for Mineral Industries.

One of the institutions existing in the country should be made most up-to-date by providing ample grants by the respective Governments. Such an institution should cater to the needs of all the provinces and States.

IV. The Question of Mineral Tariff.

The question of mineral tariff policy should be on the following lines:—

(a) Stoppage of unrestricted flow of key minerals out of India without a compensative return of equally important products.

(b) Examination of the current tariff, and suggestions for its improvement, as far as possible, with regard to minerals, and their products. The tariff policy of Australia, South Africa and other self-governing countries should be studied to frame an appropriate policy for India.

It is desirable that a definite tariff policy should be framed with respect to the following:—

(i) For minerals for which India holds almost a monopoly, and which are being exported at a wasteful rate without any duty at present, like mica, ilmenite, beryl, etc.

(ii) For those minerals for which India holds an excess of supply and plays an important part in the world production, like iron ores, manganese ore, magnesite, sillimanite, kyanite, etc.

On account of the great importance of tariff on ores and minerals, which are an irreplenishable asset of the country, it is essential that the question of tariff on minerals and their products should be examined in detail, a subject which has not received any attention till now, and that a tariff board should be instituted for the purpose.

In the case of metals and minerals which are partly produced in the country and partly imported and on which there is a custom duty on import, the local manufacturers take the advantage of this custom duty for fixing their price at the higher level. So the question of some kind of excise duty equal to the custom import duty should be taken to develop poorer ores of the country.

The policy of tariff on minerals should be based on the following principles:—

(1) In the case of those metals and minerals which are of great national importance and are used in other subsidiary industries for which there is no stock in the country, they should be duty-free so that the industries may be encouraged.

(2) In the case of those essential metals which are of great national importance for which there are ample resources in India, which should be started in this country immediately there should be heavy protective duties.

(3) In the case of important metals and mineral products for which there are big combines which will never like any other nation to rise, protection by tariff duties is necessary.

(4) In the case of those metals and minerals which are of great importance for national defence, there must be high protective duties to encourage production of these in the country, as these are absolutely essential for the nation as in the case of alloys.

(5) In the case of metals and minerals which are of great national importance, which must be conserved for the nation there must be heavy export duty so as to discourage the export of those minerals.

(6) In the case of metals like copper which are partly produced in the country and only meet a fraction of the national demand, and where the

rest of the requirement comes from foreign countries after paying heavy duty, the result is that local companies get the benefit of those high duties to raise the prices of their products by that amount above the international prices. In this case an excise duty should be charged as has been done in the case of salt, steel, etc. For the encouragement of other metal industries in India protective policy must be followed or if necessary bounties may be given in the beginning where the cost of production is high compared with the international price.

In the light of these principles a tariff list should be drawn up of the important minerals, metals and the export and import duties on them.

In the case of those finished goods which are imported at present from outside but which can be manufactured in the country out of the minerals available at present, side by side with the development of these industries there must be protection so that encouragement may be given for the consumption of Indian minerals. At present these minerals are very cheap but when they are converted into finished goods the price is increased several times.

A critical survey should be made of the Fiscal Commission's Report as far as minerals are concerned.

V. *The Question of Labour and Transport.*

Since the transport of minerals is a commercial business, it is essential that manufacturing operations should be as near the source of raw materials as possible. In order to work out the rates of transport, a standing committee, composed of representatives of the Industries, Government Railway Authorities, and the independent experts on minerals should review the source of raw materials, the site of consumption, and work out rates remunerative for the starting of basic industries. In the cases of basic industries like iron, coal, etc., the question of providing adequate facility by the railways, roads and water-ways, based upon a ten years' plan should be properly considered. As regards road transport, the possibilities of charcoal lorries, wood lorries, etc., may be explored for Indian conditions. Besides these, in fixing provincial road building programme representatives of mineral industries should have a voice. In the development of minerals occurring in far off localities like the Himalayas, the question of aerial transport (rope-ways), etc., may be considered. For development of the metal industry in India, where transport plays an important part, an impartial tribunal should examine the cost of transport per ton per mile, and fix the rate on the principle that the railway is a public utility concern. The question of freight on coal should at the same time be critically examined in this relation, and the rates so fixed as to make it possible for the outlying provinces to receive adequate coal supplies to develop the industries. The State railways should play a part in this process.

VI. *Mineral Conservation.*

The question of waste in the method of mining is a very important problem. During the last few years, the attention of the Government and the public has not been focussed on the waste in petroleum, metalliferous mines, and non-metalliferous mines like mica and it is desirable for national economy that the problem of waste in these lines should be critically examined by a committee similar to the Coal Committe which may go in detail into the matter and recommend measures for eliminating it. For the conservation of the minerals it is essential that greatest economy should be practised and efficient staff provided which can only be done by legislation.

VII. *Mineral Taxation.*

Although we are not in a position to give exact statistical information of the money recovered by the various provincial Governments by way of royalty, rents and dead-rents for their mineral products and exploitation of the mineral right the rate is exceedingly low. In the permanent settlement areas like the provinces of Bihar and Bengal, where the amount of mineral production is very high the government royalties are insignificant, while the agricultural revenue is very great.

The whole question of mineral taxation in the different provinces needs to be critically reviewed and revised. The revenue, that may arise from such a revised taxation scheme, will go a great way in financing the programme of mineral development recommended here.

VIII. *Rules and Regulations about Mining and Prospecting.*

The Rules and Regulations about Mining and Prospecting should be revised on the following lines, if necessary, by legislations:—

(1) For those for which leases are in force, or the prospecting licences have been given, the question of revision of royalties should be very critically examined, and the rate revised in view of the existing conditions.

(2) The companies holding these concessions should be compelled to train a large number of Indian technical personnels for future employment, and to employ them to the higher posts in a large measure.

(3) Rigid inspection of the mines' plants and working practices, especially petroleum, coal and metal mines.

(4) As regards new leases to be given in future, in the case of new minerals, claims of Indian nationals should be considered paramount, in such case where the State does not directly undertake.

(The mineral industry is a very important key industry and the policy followed for the key industries should be followed in this respect. Important mining concessions should not, as a rule, be given to non-Indians, on long-term leases.)

(5) In view of the fact that it is not possible for the small zamindars in the Permanent Settlement areas to develop the mineral deposits under their area, it is highly desirable that efforts should be made to acquire these underground mineral rights in these areas by the State for their exploitation, if necessary, by legislation.

In view of the detailed investigations required a special committee be appointed to study the mining rules and regulations in different countries and to devise suitable rules and regulations for India.

IX. *The Question of Finance.*

The total finance invested in mining and metallurgical industries is roughly of the order of 30 crores of rupees which forms a considerable proportion of all the industries of India.

The finance needed for the development of the proposed new mining and metallurgical industries to satisfy the present industrial needs of the country (which amounts to about 13 crores of rupees out of which some 10 crores worth can be manufactured indigenously) will be roughly 12·5 crores of rupees.

If machinery and armaments are to be included in the manufacturing programme (whose imports amount to about 17 crores of rupees, the metal contents of which alone are worth about 10 crores), this total might be augmented by another 12·5 crores. Thus the total investment needed for carrying out the programme suggested here would be about 25 crores of rupees.

This estimate is based on the present-day import of machinery, to satisfy present-day needs only. In view of the all-round development of industries likely to take place in India in future, this figure is bound to be exceeded within the next ten years.

X. *Ownership and Control of Mineral Industries.*

(1) Coal and petroleum are of vital importance to the nation. Hence they should be worked by the State either directly or through a commission on the lines of the Coal Commission of other countries. The present coal mines and the petroleum mines may be brought under the State ownership by payment of proper compensation.

(2) If it is not possible to bring the existing mines under the State control, at least for the future all the unworked coal and petroleum should be worked by the State as they are the key industries.

All the other minerals of less importance may be worked by private agencies.

(3) All the important metals like iron and steel, copper and aluminium should be worked by the State as they are the key industries.

The key minerals like coal, petroleum, iron and steel, aluminium and copper should be under the control of the Federal Government, while other smaller deposits may be controlled by Provincial Governments. In case the Federal Government takes charge of the key minerals the Provincial Governments in whose provinces those minerals occur, should have a due share of the income arising out of those.

XI. *Petroleum.*

As petroleum is very important for the nation and as petroleum has already been monopolized by the foreign companies, it is essential that any undeveloped resources should be worked by the country itself.

Due to the national importance of petroleum and its very limited resources, it is absolutely essential that some proper ways and means should be devised for proper inspection so as to avoid all wastage.

Looking to the importance of petroleum it is essential that provision should be made in India for the proper training and high grade instruction in petroleum technology.

As the foreign capital has mostly dominated the major mining and metallurgical industries, it is essential that some way should be found to bring this capital under Indian control.

5. DR. C. MAHADEVAN *and* MR. SYED KAZIM, Hyderabad-Deccan.

It can safely be asserted that the state of advancement of a country can best be gauged by its policy with regard to the exploitation, conservation and utilization of its mineral wealth. India, judged by this standard has to be dubbed very backward.

At the present stage when this country is on the threshold of industrialization, the fundamental requisites are: (*a*) the correct knowledge of her mineral potentialities, (*b*) its regional distribution, and (*c*) the location of her industries with a view to take the best advantage of the available raw materials in relation to markets. In this task, the co-operation of the geologist, industrial chemist, economist, under the aegis of the Government is essential.

It would be necessary to nationalize at least the key industries.

India can ill afford to be the milch cow of supplier of raw materials to other countries if she is to find her due place amongst progressive nations.

Taking the present mineral production as a working basis, the paper suggested a regional and rational distribution of her industries.

X. CONTROL OF WEEDS.

(*Sections of Botany, Agriculture, Entomology and Engineering.*)

DR. N. L. BOR, Dehra Dun, presided.

1. PROF. P. PARIJA, Cuttack, opened the discussion.

On the analogy of the well-known definition of dirt as matter misplaced, weeds can be defined as plants in the wrong place, from man's standpoint. To control weeds means to increase the productivity of economic plants or to increase the facilities for the transport of goods, for example in clearing the water channels.

It is not proposed here to discuss the question of the control of weeds in general but of aquatic weeds in particular. The writer's experience has been with two types of weeds, namely:—

(1) the floating exotic weeds like the water hyacinth; and
(2) the estuarian halophilous weeds like *Potamogeton*, *Naias*, *Ruppia*, etc.

The water hyacinth has been so widespread in this country that almost every one is familiar with it. Taken out of its native surroundings, it has spread rapidly by vegetative and sexual modes. Attempts at clearing it in Orissa by removing the adult plants having failed, its life-history was studied in order to explain the phenomenon of recurrence of the weed in cleared tanks.

It was found that propagation by seeds was common and that the seeds retain their viability for at least seven years. It was also found that seeds require a period of rest and as Muller had found in 1883, require alternate soaking and drying before they germinate. Tanks which support water hyacinth and dry up in summer, produce large number of seedlings after the 1st shower.

One method, therefore, for prevention of the recurrence through seeds would be to keep tanks, etc., full, so that seeds do not get a chance to germinate. This, however, is only practicable in irrigable areas.

Search for other points in the life-history at which attack could be made resulted with little success. One useful fact was that the water hyacinth sets seeds in the cold weather, although it may flower throughout spring and summer. If plants could be cleared before the setting of seeds recurrence through seeds would be lessened.

Chemical methods of control are rather difficult. Copper salts in suitable concentrations (0·18%) are effective but they affect the aquatic fauna like fish.

There does not seem to be any natural enemy in this case.

The second class of weeds came under the author's investigation when it was reported by the malaria investigation officers that these weeds break off and float in masses in the Chilka Lake in some seasons and harbour mosquito larvae. The Chilka Lake is a vast stretch of water of varying depths. The author undertook, at the instance of the Government of Orissa, to observe the weeds for a full cycle and discover any weak point in the life-cycle so that an attack might be delivered at that stage.

It has been found that *Potamogeton*, the dominant weed, has two seasons of growth in a year and these growth periods appear to be correlated with the salinity of the lake water. The salinity of the lake water shows a peak, and on either side of this peak there is an optimum salinity which seems to conduce weed growth. Higher salinity seems to control weed growth. It is, therefore, possible to control weed growth by increased salinity.

Potamogeton has vegetative mode of propagation by means of tubers. These tubers are produced and buried at a depth of 2 to 3 inches in the mud. Deeper down they perish. This is the explanation of the finding of Mr. C. C. Inglis that *Potamogeton* can be eradicated in irrigation canals by drying up the canals in summer, but it will be difficult to kill out the seeds by this means. Any large stretch of water like the Chilka Lake cannot be dealt with in this way.

It was also observed that a bivalve, *Modiola* sp., attaches itself and eats into the tissues of *Potamogeton*. Although this is perhaps one of the causes of the floating of the weed and might be exercising a certain amount of check on the growth, it cannot be used as a method of biological control.

2. Prof. B. Singh, Benares.

The problem of weed control is of greater interest in the tropics since the various favourable environmental and edaphic factors, e.g., high moisture content and high light intensity, favour not only a vigorous growth of the crop plants but also of the unwanted plants—the weeds. If weeds alone levy an annual toll of 3,000 million dollars on American agriculture, the problem before India is much more colossal and requires a more rational and scientific approach.

Weed control methods may be put into three distinct groups: (1) mechanical methods, (2) chemical methods, and (3) biological methods. The mechanical methods aim at weed eradication by mechanical means, the different cultivation or cultural practices being the chief ones. The effectiveness of mowing, crop rotation, clean cultivation, growing of smother or intertilled crops is dependent on the time and the methods of carrying out these operations and also on the weeds and crops concerned. Similarly, the effectiveness of following on the exhaustion of viable weed seeds is influenced by the frequency of cultivation, the period intervening between two cultivations, characteristics of the weeds as also the period of dormancy of their seeds.

The chemical methods of weed control employ various chemicals and fertilizers, applied either in solution or in a dry form, for the destruction of the weeds. Based on their action, the weed killers may conveniently be classified under three categories: (1) contact herbicides, (2) translocated sprays, and (3) soil sterilents. It is of interest to mention that the method of using differential spray for destroying weeds without injuring the standing crop is considered to be one of the outstanding advances in agronomy.

The effectiveness of contact herbicides, which kill the tissues with which they come in contact, is influenced by various factors whose exact nature and degree of influence still remain to be well understood. Chemical methods are, therefore, still empirical. The chief controlling factors appear to be volume-concentration relationship, species susceptibility, stage of growth of the weeds and also of the crops, prevailing conditions of weather (rainfall, dew, temperature, humidity, sunshine, etc.) during and after spraying is carried out. The mechanism of the action of the different herbicides is another debatable point, knowledge on the relative merits of the different processes on the mechanics of penetration being yet very limited.

The success of the translocated sprays which are useful in controlling perennial weeds is related to some specific conditions when the physiological response to the spray is best exhibited. Various physiological problems have arisen in the use of the translocated sprays, the important considerations being the soil moisture content, critical concentration of the poison and the acid, the stage of maturity of the weeds, the prevailing conditions of weather.

Application of plant poison to kill perennial weeds prevents cropping for some time. Further elucidation of the influence of the factors like the time of application, the stage and the condition of the growth of the weeds, the moisture and the nutrient content of the soil, texture of the soil, temperature, humidity, etc., is necessary before it is possible to predict accurately the effectiveness of any of the soil sterilents.

Biological methods, on the other hand, utilize the natural enemies of plants for the destruction of weeds. To this end, phytophagous insects have been tried with varying degrees of success in Australia, Fiji, New Zealand, etc. The chief limitation of this method is the possibility of the migration of the insects to crop plants, but this danger may be minimized if proper insects are chosen after very extensive trials. A few cases of weed control by some fungi have also been reported, but observations are yet too preliminary to allow any valid conclusions to be drawn.

In this connection, another method suggests itself: with the increasing knowledge on the various biological and physiological characteristics of the individual weed species, it is possible that some of them may be advantageously used for suppressing them. As an instance, if the critical periods of water requirement of the weeds and the crops are different or if the weeds need more water than the crops, it may be possible to render the competition by weeds less effective if water supply is withheld when weeds need it most, or if water supplied is just enough for the crops. A detailed consideration of all such factors along with an evaluation of their practical possibilities should offer a fruitful line of enquiry.

3. Dr. F. R. Bharucha, Bombay.

The problem of the control of weeds either on farms, rivers or lakes is an international and highly economic problem. For example, the control of *Eichornea crassipes* or the water hyacinth is seriously affecting the navigation of ships in the rivers of Bengal. If this problem can be solved a great amount of money and trouble would be spared. Also the spread of *Lantana camara* requires serious attention. Unfortunately, very little attention has been paid to this problem in India probably because the remedies suggested after scientific investigation seem to the authorities too expensive. They fail to understand, however, that though the remedies might be too expensive for the moment, in the end they would be very cheap, as has been proved in America and elsewhere.

But whatever may be the reason for the lack of interest in this problem, it is clear that practically no work has been done in India on it. It is, therefore, good that this discussion is held. I have consented to speak on it because it is a problem for the ecologist. Unless and until the weed problem is studied in the field, one is not likely to get tangible results. Therefore, what I would urge is an ecological approach to this problem and this can be done by various institutes in India—agricultural, forestry, irrigation as also academic.

I would suggest that the best way is to draw up a list of at least the most important weeds of India which either reduce the crop yield, affect irrigation, navigation, afforestation, etc., and then study their geographic distribution. Having done this, study their habitat very closely all the year round and set up experimental plots in various institute grounds with a view to get an idea as to the loss in money by the farmer and others by not eradicating the crop. This can then be shown to the Government and its importance realized. Once the Government recognizes this fact, it will help ecological investigations of these weeds. If the results of some of the investigations show a necessity of passing legislations for the control of weeds, then they may be introduced. It must be realized and emphasized that some of the remedies might be very costly at the beginning but they are bound to help the nation in the long run.

4. Mr. E. S. Narayanan, New Delhi.

Biological Control of Weeds.

Though superficially the problem of the Biological Control of weeds or pest plants appears to be similar to the Biological Control of insect pests it must be emphasized here that the one is the very inverse of the problem of the other. In the case of the problem of the Biological Control of insect pests the latter attack plants of great economic importance to man and naturally the insect that attack these plants are classed as Insect Pests. The parasites that attack these pests and bring about a reduction in their population are classed as beneficial. In the case of the Biological Control of weeds the case is diametrically the opposite. Though weeds have their place in the mosaic of the divine scheme of things man has no more use for them than he has for the injurious insect pests, reptiles and mammals. Only in one respect are both the problems similar and that is both the insect pests and the plant pests have multiplied with alarming rapidity when they have been accidentally introduced in other lands without their natural enemies that keep their population in equilibrium in their native soil. When this phenomena occurs the insect constitutes a serious threat to the crops in the new lands whereas the plant pests by rapid sexual or vegetative reproduction invade and colonize large areas of lands as to render these areas unfit for cultivation.

Certain fundamental principles must govern the introduction of the insect enemies of plant pests. Care should be taken to see that when an insect is introduced to check any plant pest no natural enemy of the insect is accidentally introduced along with it. Very great precaution should be taken by careful study and experiment that the insect to be introduced does not attack any plant of economic importance in its new home and that the insects attack only the genus to which the plant pests belong or allied species of absolutely no economic importance. Thus an exhaustive test is necessary, before the introduction of an insect to control a noxious weed.

The earliest attempt to control a weed by its insect enemies was by Koeble of the United States Department of Agriculture in the control of Lantana in the Hawaiian islands. Hillebrand, the distinguished Botanist of the islands, introduced *Lantana camara* for ornamental purposes in 1860. The shrub subsequently became a scourge to the pastures. In 1898 Koeble visited Mexico and bred some insects from the seeds of *Lantana.* He made another journey in 1902 with the object of securing promising enemies for the purposes of introduction in the islands. Twenty-three species of insects were sent to Perkins at Honolulu of which eight became well established. The most effective was the Tortricid moth *Crocidosema lantana* Busck whose larvae bore into the flower stems and feed on the flowers and fruits.

The spread of the prickly pear in Australia is an example how a plant pest devoid of its natural enemies can invade quickly large areas and render them absolutely unfit for cultivation. In 1925 the area in Queensland and New South Wales alone amounted to 60,000,000 acres. In the same year it was estimated that the plant pest was spreading at the rate of one million acre yearly. A large number of natural enemies were introduced after elaborate tests and of these the moth *Cactoblastis cactorum,* the Cochineal *Dactylopius tomentosus* the plant bug *Chelinidea tubulata* and the red spider *Tetranychus opuntiae* became well established. Of these *Cactoblostis cactorum* is the most important. The rate of increase of the prickly pear has been arrested and today less than ten per cent of the former infested area remains. In Madras *Opuntia dillenii* has been effectively controlled by the Cochineal *Dactylopius tomentosus.* The experiment began only in 1927 and by 1941 it is expected that 114,000 sq. miles of prickly pear will be cleared.

In the Fiji islands it is claimed that the shrubby weed *Clidemia hirta* has been controlled by the Thirps *Liothrips urichi*. Attempt should be made in India to control the water hyacinth which is one of the present problems of Bengal.

5. DR. H. CHAUDHURI, Lahore.

Weeds of our cultivated fields are wild herbs springing where they are not wanted. These unwanted plants compete for food materials with crop plants and impoverish the soil.

Some weeds like *Striga* and *Orobanche* may parasitize certain of our crop plants and cause enormous losses. In the Punjab it has become a problem to grow jowar in fields where *Striga* makes its appearance. Control of *Striga*, if not undertaken, at the very beginning, becomes almost impossible to check later on. These pests produce innumerable minute seeds. For control they have to be weeded out when they first make their appearance in the field and before they flower and produce the seeds. Legislation for compulsory weeding out will be useful. Crop rotation in infected fields is highly recommended.

Other weeds provide abodes for dangerous pests and diseases and may directly prove poisonous or injurious to men and animals when mixed and taken in along with crop plants.

Weeds act as alternate hosts for many pests. Breeding a fully resistant crop is not always practicable. Removal of the weeds helps in controlling the pests. Certain weeds like *Euphorbia dracunculoides* (*Kangi*) growing in barley fields and whose seeds become mixed up with barley at the time of threshing have been responsible for great losses. A large consignment of barley purchased by the military department had to be rejected because the horses refused to feed on them. Some kind of itching sensation was produced on the throat of the animals. I examined a sample from that consignment and found that the barley was mixed up with seeds of *Kangi* which produced the itching, not due to any poisonous principles present in the seeds but, due to the seeds being infected by some species of *Ustilago* which in culture produced cyanogenetic glucosides and that was responsible for causing the itching sensation. For control, even if weeding proves impracticable, it will not be at all difficult to separate them by passing through an appropriate sieve after the threshing is over.

Oil from the seeds of another weed, *Argemone mexicana*, has disastrous result on those human beings who consume mustard oil. A minute dose of the oil of *A. mexicana*, if administered internally, will produce similar symptoms as found in an attack of Beriberi. The seeds of *A. mexicana* look very similar to mustard seeds and these weeds grow in the mustard fields. They flower and ripen at the same time as those of the mustard and accidental mixture of the seeds at harvesting is likely (though deliberate adulteration is not ruled out). For control, the *Argemone* plants may be easily weeded out when they flower and become noticeable due to their big yellow flower. Legislation in this direction will be welcome.

In case of weeds propagated by seeds, reaping of crop prior to the setting of seeds is a common weed control measure. Of therapeutic measures, $CuSO_4$ spray, the strength of which is to be ascertained by experiments, is recommended. The leaves of cereals are thin, narrow and erect and hence the spray trickles down and does not injure them. In case of weeds with a spreading habit it is effective.

6. DR. T. S. MAHABALE, Ahmedabad.

Eradication of weeds from their manifold habitats is a problem of some economic importance in an agricultural country like India. The main difficulty in solving this problem arises out of the fact that a measure which may affect a weed or weeds may also affect the other plants of economic importance in the midst of which the weeds grow. A remedy against a weed, therefore, should be such as will affect the weed but not the plants of economic importance to man. One of such remedies employed by the villagers in parts of Northern Gujarat has been brought to the notice of the author through the good offices of his friends and is described below.

In many parts of Gujarat a large number of ponds are formed during the monsoons. Some of these are permanent and others temporary. They support a rich algal vegetation and many flowering weeds like *Potamogeton cripus*, *Nias majus*, *Ceratophyllum demersum*, etc. Towards the end of December the ponds begin to dry up and with them the algae and other vegetation. During this period they are slowly rotting and emitting foul abnoxious smells in the surroundings. The water is polluted and cannot be used by the villagers or by their cattle for drinking and other purposes. Under such circumstances the villagers collect a large number of twigs of *Capparis aphylla*, dry them out partially and throw them in the ponds. As the shoots of *Capparis aphylla* begin to rot, the algae and flowering weeds also get decomposed and the whole mass of organic debris at the surface of the water settles down to the bottom of the ponds. The water becomes clear once again and is used for drinking and other purposes by the villagers.

What exactly brings about the decay of weeds in the ponds by this method is not known. It may be that *Capparis aphylla* may be liberating some substances during decomposition which have a toxic action on the weeds, or it may be encouraging a succession of organisms like bacteria which attack *Capparis aphylla* first and the water weeds afterwards. or it may be due to the joint action of both these causes. Anyway the method deserves further investigation at the hands of those who are interested in the problem of the control of weeds in fresh water reservoirs.

7. Dr. V. K. Badami, Cuttack.

The Indian cultivator knows full well how to destroy the annual weeds and many deep-footed weeds. In general his cultivation methods are clean and efficient. Previous speakers have referred to some special weeds. They are important and require immediate measures to control and check them. But from an agricultural point of view we have far more important problems to solve. For instance hariyale (*Cynodon dactylon*) is a great menace in Black soils. At great cost it can be destroyed by digging or deep ploughing. Cheaper methods are necessary. Hariyale in sandy or loamy soils is very difficult to eradicate. Similarly nut grass (*C. rotundus*) is a regular menace especially in garden lands. They spread by roots and seeds. The corms are formed in a series, deep under the surface soil. The hard, shiny leaves are not easily attacked by chemicals. I would, therefore, suggest that such problems as these, as are important in each province, deserve special attention of the botanists. A careful study of their life and habit of growth, their structure and environmental requirements may reveal valuable information which would be useful to the practical agriculturist.

8. Mr. N. L. Dutt, Coimbatore.

The raising of a crop like sugarcane is, particularly in the early stages of its growth, literally a battle with weeds. Indeed, it is the opinion of some that the weeds cause more loss to agriculture than insects and fungi taken together.

In sugarcane it has been found that varieties whose tillers are recumbent in the early stages cover the space between the rows, thus checking, if not completely keeping down, the growth of weeds. One such variety is Co. 213.

Considerable work has been done in other countries on the chemical control of the several weeds of sugarcane. It is proposed to mention here about the root parasite Striga which assumed the size of a menace to the Nursery Plots at Coimbatore, ten years ago. The sugarcane seedlings in the Nursery are very valuable to the Coimbatore Station as its main work depends on them.

In the finding out of the control measures, care had to be taken that the treatment was not so drastic as to kill the young sugarcane seedlings along with the parasite. After trying several methods, the one found most effective was to treat each Striga plant individually. A depression was scooped round the Striga plant and filled with a 2% solution of copper sulphate. In this way the entire plant—the above-ground portion as well as the roots—was killed. Treatment with the above chemical, of which one application was enough, effected Striga but not the sugarcane seedlings. The method is laborious but considering the importance of the seedlings to the Station, no effective method was felt to be too laborious.

Striga later attacked the main plots. The remedy found effective was to dig a depression round the cane plant and filling it with a 3% solution of copper sulphate. This strength has no evil effects on sugarcane but completely kills the Striga. The seeds of Striga are said to be viable for over 20 years. It is obvious, therefore, that the parasite should be destroyed at the vegetative phase of its life-history and that too root and branch. Because of longevity of Striga seeds, it is best to encourage the plants to come out by planting hosts, like cholam or sugarcane, and then destroy the plants thoroughly and fully.

9. Prof. J. C. Luthra, Lyallpur.

He drew attention to the urgent need for some suitable legislative enactment in the provinces of India on the lines of the the Madras Agricultural Pests and Diseases Act of 1919 for effective and compulsory control of weeds and pests. There is no hope for controlling widespread weeds unless concerted action is taken.

Mentioning control measures of particular weeds, he stated that in the case of herbaceous weeds like *Chenopodium*, *Chicory*, *Amaranthus*, etc. which are annuals, it is distinctly worth while to plough up the weed seedlings soon after they appear on irrigating the fields. If this operation is repeated twice before the crop is sown it greatly reduces the weeds at an early stage. Perennial weeds like Johnson grass, spear grass and Kans can only be controlled if the underground root stock is dug up and destroyed. As regards *Calotropis* and *Kans*, gas tar has been found to prevent sprouting of their roots when they are thoroughly soaked in it.

Carthamus oxyacantha (Thistle or Pohli) is a very troublesome weed found in waste places and in wheat, barley and gram fields in the Punjab. It is successfully killed by using a 1% solution of sodium arsenite. A 5% solution of common salt sprayed on *Euporbia prostrata* (called red spurge and a common weed of tennis lawns) has proved very effective in suppressing this weed.

10. Rao Bahadur N. S. Joshi, Sholapur.

The weeds which the speaker had occasion to deal with were those met with in the perennial canals in Bombay Deccan. The weeds commonly met with are:—

(1) *Vallisneria spiralis.*

(2) *Potamogeton perfoliatus.*

P. pectinatus.

P. indicus.

(3) *Ceratophyllum demursum.*

(4) *Hydrilla verticillata.*

The last two are found in canals with very low velocities (0·5 to 1 foot per second) only, particularly the Mutha Right Bank Canal. The first two varieties are common on canals with velocities above 1 foot per second but below 2′ per second. It is however noticed that in the Nira Left Bank Canal when the velocity is more than 2 feet per second in embankments and partial cutting and where it is even more, i.e. between 3′ to 5′ per second in cutting (situated 2 to 5 miles apart) the growth of weeds is well under control and only *Vallisneria spiralis* can exist. This can be attributed to no other factor than the higher velocity. It is doubtful however whether this is due to the direct physical action of velocity on the leaves or other parts of the plant or to the turbidity created which ultimately cuts off light from reaching the bottom of the canal. This latter theory (cutting off of light) explains the stunted growth of *Vallisneria spiralis* in Nira Canals, but it cannot explain the absence of the *Potamogeton* varieties in that canal. *Potamogeton indicus* and *P. perfoliatus*, however, have long stems and leaves which can float on the surface and it does not appear that these varieties can be said to be subject to the effect of turbidity in its property of cutting off light. The plants are probably subject to the direct action of velocity (in excess of 2′ per second) and the leaves and/or the stem are subject to a direct pull. This has to be proved by experiments.

Various methods such as removing weeds bodily at intervals of a month or two, were tried on the Mutha, Pravara and Godavari Canals but simply resulted in the conditions continuing as they were or actually getting worse. Application of chemicals like copper sulphate was out of the question both due to the high cost and poisonous effects to human beings, cattle or crops. Simpler, practical and economic methods had therefore to be devised and naturally ecology had to be studied. Observations showed that weeds were profuse in certain canals but were markedly wanting in others. It was observed that they were a pest in the Mutha Canals and also in Pravara and Godavari Canals but the Nira Left was particularly free from them, though even the last had its own quota of *Vallisneria spiralis*, but no others. The Pravara and Godavari canals had the *Potamogeton* species while the Mutha Canals had in addition the *Ceratophyllum demursum* and *Hydrilla verticillata* which were found in no other canal. This led to different theories as under:—

(1) That the lake at head of Nira Left kept the waters turbid and this resulted in light being cut off from weeds to live or thrive. This could not however explain the want of *Potamogetum* varieties (with floating stems and leaves at surface of water) though it explains the hampered growth of *Vallisneria spiralis*. Again the fact that the Pravara and Godavari Canals had heavy growth of both *Vallisneria* and *Potamogeton*, in spite of the Ozer and Madhmeswer weirs respectively, could not be satisfactorily explained by this theory. On the other hand, the Shetphel channel taking off from a very small tank had but few weeds.

(2) That it was the silt deposited on beds that was mainly responsible for the heavy growth of weeds. This theory too did not stand as the Shetphel channel (with a tank at its head) which had a lot of silt did not have much trouble with weeds. It was also noticed that non-perennial canals did not carry weeds though they had heavy quantities of silt (it may however be noted that Upper Indian canals have very coarse silt and this may be the additional reason for want of weeds in them). Lastly the Nira Left itself had many lengths full of silt but had no weeds there.

(3) That it was the high velocity in the Nira Left that was mainly responsible (as it acted in two different ways), particularly the physical action. The speaker carried out certain experiments at the Royal Institute of Science and found that *Vallisneria* thrived well, under velocities

obtained in Nira Left. Again other canals did continue to have weeds at places while the Nira Left had none in certain spots, particularly embankments, though the velocity in both these places was the same. This explanation too was therefore unsatisfactory.

4. That the effects of high velocity in that it kept waters turbid that was responsible for the growth of *Vallisneria spiralis* while the high velocity checked the growth of *Potamogeton* as the combined result of silt in suspension closing up the stomata in the leaves of weeds and also of velocity acting physically. The Nira Left had the advantage of large and medium cuttings at intervals of 5 or 6 miles where waters were churned with the result that silt continued in suspension. In fact, observations showed that silt got finer as one went towards the tail.

Ultimately, it was noticed that the last theory gave the correct explanation. Mr. Inglis was the exponent of theory No. 1. The real solution of the whole was however found in arranging for regular closures, i.e., running a canal from 5 to 6 days and finishing all irrigation and then closing it completely for 4 to 5 days (in every turn of 10 days). This was a cheap and most practical method. This created very unsuitable conditions for the weeds, for though one closure did not kill weeds, a large number of them following each other at intervals made life very difficult for them and they died ultimately. These closures automatically resulted in keeping waters turbid and also getting the full designed high velocity in addition to starving the weeds for long periods at short intervals.

The speaker thought that the killing of weeds in Chilka Lake mentioned by Prof. Parija was really an outcome of the turbidity caused by the monsoon floods and not of the increase in salinity. It was seen on the canals in Bombay-Deccan that weeds thrived well in drainage channels where salinity was high. The observations about growth of weeds being reduced after the Lake began to lower, really indicated, the speaker thought, that the weeds got cut off from light during monsoons due to turbidity and perhaps also as a result of the stomata being closed by silt and not of the increase in salinity.

It is to be noticed that closure in summer alone is not sufficient to kill weeds as the plants have tubers, nor is the removal of silt the real solution (mentioned by Prof. Parija to be the method advocated by Mr. Inglis), for silt will deposit again. The cost of removing silt is so large that such a proposal is impracticable and also unnecessary and ineffective.

11. Dr. H. S. Pruthi, New Delhi.

XI. THE UTILIZATION OF RESULTS OF AGRICULTURAL RESEARCH FOR INCREASED MONETARY RETURN TO THE CULTIVATORS.

(*Section of Agriculture*)

Mr. P. M. Kharegat, New Delhi, presided and opened the discussion.

In initiating the discussion Mr. Kharegat said that there could be no question about the need for utilizing the results of research and we may take it that it was necessary to do so in order to ameliorate the lot of the cultivators. We have to consider as to how best to do it. First of all, research should be such as to be utilizable under the conditions obtaining in the cultivators' fields. It should also be such as would solve some practical difficulty of the cultivator. It is this aspect which is sometimes lost sight of, and it is here that mistakes initially occur. The research must be economic and it should always be remembered that it is incomplete so long as it has not been tried on the cultivator's fields. The above does not apply to fundamental research which is undertaken to unravel the basic causes of phenomena, but even here every effort should be made to consider its practical implications.

The next step was to find out how the cultivator could best utilize results of research. The Departmental advice should be very welcome to the cultivator provided the Extension method comprising Demonstration and Propaganda is on sound lines. It was very essential that the instructions for guidance to the cultivators should not only be detailed, but absolutely precise and clear cut, admitting of no ambiguity. Cases have been known where the Demonstrators themselves did not know what exactly to recommend to the cultivator. In their anxiety to please their superiors they sometimes make recommendations irrespective of their utility or applicability to the particular conditions obtaining in the ryot's fields. Another important condition was to select a suitable area and to lay out a quantitative plan. The area selected may preferably be a small one, say a village, and it should be treated as one Estate in which all the known improvements are introduced. Demonstration should be held side by side with the cultivator's methods. This will enable the cumulative effect of all the improvements to be felt by the cultivator. For grading, cleaning and marketing of produce it will generally be found that it is best to set up organizations on co-operative or other basis. The question of finance was also a very important one, but it was largely a problem for the Local Governments.

We may now consider the difficulties in the way of the satisfactory utilization of results of research by the cultivator. The conservatism of the cultivator is one. It is said that the villagers are ignorant and illiterate, but if the cultivator is convinced that a particular improvement is profitable, he is often able to find the money to purchase the improved seed, as for instance of improved sugarcane varieties or Punjab-American Cotton. The second point is the lack of clear cut instructions by the Propaganda staff to which reference has already been made. Their main function is to do Propaganda, and yet it is in this particular direction that their training is most deficient. They should be properly fitted out for their most important work. There is great room for improving the quality of the staff for Propaganda work. Lastly a word about the quantity of produce and the price realized in the market. A certain Demonstrator was once advocating to a gathering of villagers that if they grew sweet potatoes it would bring them profit of Rs.28 per acre. An old villager got up and enquired what would happen to the profit if every one began to grow sweet potatoes. This is the crux of the situation. There are bound to be difficulties unless prices can be stabilized or production can be adjusted to demand.

2. MR. K. RAMIAH, Indore.

The main attempt of the Agricultural Departments all over the world is to increase the return per acre to the cultivator. This is sought to be achieved either by increasing the acre yields or reducing the losses that occur due to pests and diseases or by both. The acre yields can be improved by taking to better methods of cultivation, by improving the fertility of the soil and by the growing of improved varieties of crops. While the first two might mean an extra investment on the part of the cultivator, the growing of improved varieties does not involve any additional expenditure, and is most readily appreciated.

Crop botanists working all over India are endeavouring to evolve improved types, and such types already available are many in number, each suited to particular tracts in the various provinces and States. In spite of the considerable achievements on the part of Crop botanists, the total area devoted to improved varieties of several crops however is still small, the only exception being sugarcane.

Even within a province the conditions of soil, rainfall and climate vary so much in different tracts, and this involves the breeding of special types for each individual tract and hence the large number of breeding stations for each crop, as in Madras for rice and cotton and in Bombay for cotton.

While the responsibility of the plant breeder ceases with the testing and final issuing of improved varieties, their multiplication in a systematic manner and making them available to the cultivators are beyond his sphere. Unlike advanced countries of the west, there are no seed-men dealing with agricultural crops to whom such work can be entrusted, and there are also no Seed Acts in force compelling growers to sow only accepted and certified varieties. The work has necessarily to be managed by Govt. Agri. Departments, but, unfortunately, the time and money spent on this activity is still limited in spite of its great usefulness to the country.

In the case of industrial crops like cotton, besides the grower the industry is also interested in the problem, and the question of seed multiplication and distribution receives considerable attention on the part of the Indian Central Cotton Committee, who also undertake to finance special seed-distribution schemes. It is possible in this case to make fairly reliable estimates not only of the areas under the improved types, but also the gross value of benefits derived by the cultivators. In the case of other crops the seed multiplication and distribution are not so well organised except in some provinces, and there is also no means of making a reliable estimate of the area under the improved types. Until recognized non-official agencies, as for instance the co-operative societies, spring up in particular tracts to whom the work can be entrusted, it is necessary that the Governments concerned should pay considerably greater attention to the question than at present.

Spreading of improved types of crops is a line of activity where the benefits to be derived by the cultivators can be easily demonstrated and from the experience available in a province like the Punjab, seed distribution schemes could be made self-supporting without any ultimate financial commitment on the part of Government. There is no doubt that any seed distribution scheme will immediately result in increased production and this is the most tangible way of bringing home to the cultivators the benefits of research carried out by the agricultural departments.

3. Mr. R. G. Allen, Baroda.

He said that research must be regarded as the spearhead behind which there must be efficient organization and good financial support. He instanced the good work done by the Indian Central Cotton Committee and also explained in detail the system followed in Baroda whereby the results of research are propagated rapidly and over a fairly large area of the State among the cultivators, who are also provided with technical advice and necessary machinery on part payment for adopting modern agricultural practices.

4. Dr. H. K. Sen, Ranchi.

He dealt with the subject from the point of view of lac.

Bringing the results of research to the cultivator has for its purpose improvement in yield of a crop on the one hand and quality on the other. But this can primarily relate only to such crops, the development of which for internal consumption is found necessary and exports form a minor channel of disposal. Those food crops which are as yet insufficient for our population, must necessarily be augmented by encouraging the cultivators to take to improved methods discovered and established after careful experimentation on large scale. To earn their confidence and to induce them to practise such tested methods, financial aids wherever required and distribution of seeds would undoubtedly be the essential pre-requisites. The nature of aid may vary according to the type of crop. Special products like lac have their peculiar difficulties, enhanced further by the fact that about 97% of this commodity finds its market abroad. To this may be added the fact that violent fluctuations in the price of lac place the cultivator in an uncertain position with regard to the monetary value of his crop. His poverty prevents him from taking the fullest advantage, as he often has to cut his crop earlier before its full maturity in order to find his cash, resulting simultaneously in brood famine.

It seems therefore necessary, for the cultivator to enjoy the fullest benefit of his crop, to set up organizations to take over his product at a reasonable price. This would constitute a very important step towards ensuring better monetary return for his labour. An attempt in this direction was made by the Congress Government of Bihar by drafting a Lac Control Bill. But the Bill went no further owing to the resignation of the Congress ministry. If the cultivator is left to shift for himself he would be constantly tossed and buffetted by that relentless law of supply and demand. He considered, therefore, that a sound system of marketing should be an essential factor if the cultivator is to earn more than what he is getting now. The value of the practical application of research is by no means depreciated, but the ultimate disposal of a commodity appears to me to be the most important item for research and organization. A lesson may be taken from the Citrus fruit industry in California, which is so well organized by a Syndicate that the growers have been making a steady income now over 12 years since this organization began working. By the setting up of such selling organizations, most agricultural commodities could be saved from the frequent blasts of speculation and the profession of agriculture itself might be made attractive as a career.

5. Mr. P. H. Carpenter, Cinnamara (Assam).

He spoke on the utilization of research in tea crop. He drew particular attention to the following points:—that it is necessary for the scientific workers to visit the cultivators frequently and then to carry out investigations to devise means for providing a remedy to his difficulties. This was the method adopted by Dr. Mann when he initiated the Scientific Department of the Indian Tea Association. It is of primary importance to obtain the confidence of the cultivator. After that further elaboration of experiments will give further data on which still more efficient methods can be introduced. This was exemplified in the manuring of tea and also in the case of cultivation, that is, soil stirring for the suppression of weeds, etc. The result of this policy has been the increasing demand by the cultivators (planters) for scientific advice.

6. Mr. S. S. Bhat, Baroda.

For the utilization of results of research for increased monetary return to the cultivator, fruit growing stands on rather a different level from agricultural crops. Both research and the dissemination of its results among cultivators take a much longer time than what is required for agricultural crops. Fruit growing is also a profession that requires more capital investment and has to wait for returns. As such, we have to use information and results obtained outside the locality concerned, and adopt other methods than the use of demonstration plots in cultivators fields, etc., which are not practicable in the case of propaganda for fruits.

In the Baroda State, several thousands of Kew pine-apple suckers have been successfully introduced in private plantations, and three large fruit shows were held among other activities for extensive propaganda. For intensive work, the State Government have given liberal facilities to the growers in the Dhari and Kodinar talukas. They have offered without cost cultivable waste land, free of assessment for the first seven years, half assessment from 7 to 15 years, and full assessment thereafter; a bounty of Rs.20 per bigha of new plantation raised during the first five years of the scheme. Besides, two fruit nurseries have been opened. Work on these lines is very satisfactory.

Apart from these methods of direct approach to the grower, it would be advisable to give a much stronger bias to agricultural subjects in our system of primary education in general. Our population is rural and our schools are rural. The boys usually give up studies after the primary standards and take to agricultural vocations. It is therefore natural that they should be given, by way of object lessons, what may be useful to their undertaking later on, and not abstract subjects. In this way the rural population can be made 'agricultural-improvement-minded' and they will be more receptive for the results of research in agriculture than they are now.

7. Dr. V. K. Badami, Cuttack.

Previous speakers have referred to the various aspects of taking results of research to the cultivator. I shall attempt to deal with the broader aspects of the problem. It is no doubt very necessary to make improved seeds in large quantities available to the cultivators at cheap prices. Similarly, it is necessary to give them cheap manures and efficient implements. Agencies should also be created to teach the cultivator improved systems of cultivation, manuring and profitable systems of marketing their produce. These are all special aspects requiring careful attention. My conception of the general improvement is that the lot of the farmer should be made happier than what it is at present. In the first instance he must have enough to eat and clothe himself, and all attempts should be made to meet his minimum requirements. We should keep him healthy and strong, and improve his efficiency as a citizen of the country. For a Rice Province like Orissa, the minimum requirements are; rice 20 oz., pulses 3 oz., at least half to one ounce fat, and plenty of fruits and vegetables. A careful inquiry should be made to see whether the average cultivator gets this minimum requirement. Village surveys will show how far such minimum requirement could be satisfied. In Orissa nearly 400 villages have been fully surveyed, and in most cases it is seen that the production is far short of the requirements to maintain the people in an efficient state, either for work or for fighting diseases and adverse conditions. The cattle population and milk production show clearly the appalling state of the ryots. In many cases milk production is even less than half an ounce per head of population. Compare this with the milk production in some western countries where it is said to be over 20 or 25 ounces per head of population. We cannot expect to build strong and healthy people with such low consumption of dairy products. It is, therefore, necessary to take up the village as a unit, and see how far improvements could be affected. It may not be out of place to suggest that at least one model village be established in each district, for others to emulate. Such an improvement requires money, and it is for the administrators and legislatures to find ways and means of providing funds for such large scale operations.

It is said that the 6% of improvement or so, now found in Indian agriculture, is a lamentable state of affairs. I, for one, am not in the least disappointed or distressed. It looks as though 6 to 10% seems to be common for many other features relating to life in India. After 100 years of organized education in India, the percentage of literacy is still 6–10%. After knowing fully well remedial measures for cholera, small-pox and malaria the havoc caused by those diseases is still very high. Considering the slow progress everywhere, we may feel flattered that we have made rapid strides in agriculture. But even if 6% of the agricultural population tried improved methods at least 30% people would watch the results. There must be some powerful reasons like want of cash, facilities, or defects in the relation between the tenant and landlord which must be responsible for preventing those people from adopting these improvements. It is therefore necessary for us to study all details in organizing various agencies which would try to take the fruits of research to the doors of the cultivators. There is no use in attempting to introduce a few improvements here and there. Every effort should be made to take the village as a unit, and see that useful and permanent improvements are effected in such a manner as to improve the general condition of the village as a whole. Unless the problem is treated in this manner, there cannot be any permanent improvement, which would be appreciated by the people or be of much benefit to the country. I would, therefore, suggest that in all the plans we draw up, we should treat the problem as a whole and not piecemeal. If the results of research cannot improve the lot of the villagers in a tangible manner, then all the money spent on such research is a sheer national waste. But we are confident of planning proper programmes provided sufficient funds are placed at our disposal. What we are in need of is a planned programme of work for specified terms of years and sufficient money to carry out such programmes.

8. Dr. B. P. Pal, New Delhi.

He briefly indicated the benefits that had already accrued to the cultivator as a result of the Indian wheat breeding work. He said that the improved types as yet covered only about 7% of the total wheat area in India. In seeking to extend this area, it was necessary to make arrangements for distributing pure seeds. He particularly emphasized the necessity for seeing that so-called pure seed was really pure and gave several instances from his experience where seed distributed was said to be of certain improved types but was actually something quite different. He also pointed out the necessity of keeping data on the varieties under distribution by agricultural departments to see exactly what was happening to the new strains under various conditions.

He also pointed out the importance of quality. He suggested that wheats having similar grain but differing in other characters should be bred with a view to obtaining varieties suitable for different conditions but yielding grains of uniform quality.

9. Prof. P. Parija, Cuttack.

He spoke on behalf of the middle class cultivators, and explained the difficulties encountered by them in quickly obtaining improved seeds for their farms. He emphasized the necessity for setting up some organization between the central research organization and the middle class cultivators by which this difficulty may be obviated in future.

10. Mr. G. S. Kulkarni, Gwalior.

He explained certain items of research in Gwalior.

11. Mr. N. L. Dutt, Coimbatore.

The research on sugarcane is being done in order to benefit the growers of cane and also the factories. In certain parts of India (Bombay, Deccan, for instance,) the factories own large cane plantations. These have to be interpreted as growers on a large scale. For the small grower the main thing to be kept in view is the gur or jaggery. No cane variety should be advocated whose gur is not saleable. The second point on which stress may justifiably be laid is that a multiplicity of varieties should be avoided so far as the small-scale grower is concerned. It is enough if he has on his hand two or at the most three varieties. Thirdly, when once the usefulness of a variety has been tested thoroughly, the organization for the distribution of seeds of the improved variety should be such that a large number of cultivators may be in a position to reap the benefit from it. In Java after it was known that POJ. 2878 was a useful cane to grow, it was successfully distributed to over 95% of the area in less than half a dozen years.

Sugarcane is a 'money' crop which occupies the land from 10 to 14 months and entails a considerable outlay on the part of the cultivator. Increased outturn is ensured by adopting improved varieties into cultivation and in this the sugarcane crop has been fortunate, because the work conducted at the Imperial Sugarcane Station at Coimbatore has been of the greatest value. It is necessary to pay more attention to the betterment of the crop by employing better methods of cultivation and manuring and by controlling pests and diseases, and in this latter direction, much leeway has to be made up.

The task of the Coimbatore Station in breeding improved varieties for all parts of India has been one of great difficulty. The continental size of India with its considerable variation in conditions of climate and soil, the low yields of the canes in cultivation, the technical difficulties involved in the handling of the breeding material due to the small size of floral organs, defective fertility of certain and sterility of other parents were some of the difficulties that had to be overcome.

One of the revolutionary steps taken by Coimbatore was to utilize the wild cane (*Saccharum spontaneum* or the weed known as *Kans*) for crossing with the Indian and foreign canes. By elaborate stages of breeding, Co. canes possessing the qualities of high yield and resistance to extremes of temperature and others with relatively high sucrose and early maturity were successfully evolved. The Co. canes between themselves now occupy over 80% of the cane area, and it is estimated that the gain to the cultivator because of growing Co. canes is about *ten crores of rupees* per year.

The Coimbatore work has included the breeding of thick canes. The fruits of this work have done very well and have already reached the cultivator. The Co. canes are also helping the sugar industries of South Africa, Australia, Louisiana and Spain, thus enabling the utility of Coimbatore work to all the five Continents.

The above qualities of the Coimbatore canes have, with the help of tariff protection, changed the complexion of the Indian Sugar Industry. India is now no longer an importing country but one which not only fully meets her own sugar requirements, but has also a surplus every year. This surplus sugar, in fact, tends to become a problem by itself during certain seasons.

There is no doubt that the results of Coimbatore work are being utilized. But the average yield of cane in India has increased by only 50%: it was about 10 tons per acre before the advent of Co. canes and is now about 15 tons. It is well known that Co. canes quite commonly yield 20 to 25 tons per acre. The reason why the average yield is still low is because of defective methods of cultivation and manuring and indifferent control of pests and diseases. If due attention is paid to these, the average yield is likely to rise to 18 or 20 tons.

Are the above steps sufficient to enable the industry to stand on its own legs? Unfortunately not, because there are still many gaps in the breeding work. The 'early' and 'late' canes have yet to be improved to bring them in a line with the general purpose canes in point of yield.

The maturity of late canes and recovery of sugar from them requires improvement, and as regards varieties, resistant to pests and diseases we are as yet only at the beginning. Indeed none of the commercial Co. canes are satisfactorily resistant to pests and diseases. It may be said therefore that while the tariff is in force, the breeding activities should be intensified and every effort made to breed and make available to the cultivator canes whose cost of production is strictly comparable with that in other parts of the world.

12. Mr. D. N. Wadia, Colombo.

He said that he was glad to note that this discussion represented a liaison between the Imperial Council of Agricultural Research and the Indian Science Congress.

13. Sir V. T. Krishnamachariar, Baroda.

He said that in his opinion the State should take up the responsibility of multiplying improved seed and supplying it to the farmers. As regards the cultivators' readiness to take up improved methods of agriculture or obey acts and legislative measures bearing on the cultivation of crops, he was of the opinion that the cultivator is ready to do so provided it is found remunerative to him. In Baroda they had found no difficulty in these respects as the work done by the Department of Agriculture had prepared and educated the cultivator. It was possible in many cases to pass the acts and rules and enforce them in a very short time with the willing co-operation of the growers.

14. Dr. Nazir Ahmad, Bombay.

He said that the question of disposal of old seed from the cultivators should also be considered, because left to themselves, the farmers are inclined to use inferior seed rather than obtain improved seed. He also suggested that any organization which may be set up for conveying the results of research across to the cultivators should take into account the enlightened and large estate holders such as the tea growers as well as the uneducated and small farmers possessing very small holdings.

In closing the discussion the Chairman, Mr. Kharegat said that the discussion had brought out some very interesting points. In particular it was necessary for research workers to ascertain the problems of the cultivators and find out what they needed. The whole subject was now under the consideration of the Imperial Council of Agricultural Research, and the various points mentioned in the course of this Discussion would no doubt receive due consideration.

XII. IMPROVEMENT IN AGRICULTURAL IMPLEMENTS AND MACHINERY.

(*Sections of Agriculture and Engineering.*)

Dr. Nazir Ahmad, Bombay, presided.

1. Dr. A. H. Pandya, Sibpur (Calcutta).

It is well known that the economy of India is largely dependent on agriculture which constitutes the only means of livelihood for the vast majority of her people. Everything should therefore be done to improve agricultural methods and to introduce improved implements and machinery. The United States of America and Soviet Russia have achieved remarkable results in this respect and there is much we can learn from them. We must not, however, overlook the conditions peculiar to India and blindly copy the systems evolved in other countries.

The principal difficulties in introducing intricate and expensive machinery in India may be summed up as follows:—

(1) Poverty of the agriculturists.
(2) Small size of farm holdings.
(3) Lack of primary and vocational education in the villages.
(4) Necessity of importing machinery from abroad.
(5) Abundance of cheap labour.

Before the full benefits of agricultural machinery can be derived, it is necessary to form 'combines' of smaller holdings. It may also be found necessary for a village to own and operate machines on a co-operative basis with Government aid. This may require legislation of a most difficult nature.

The next step should be the education of the Agriculturists in Elementary Mechanical Engineering because all modern machinery requires great care in handling, operation and repairs. It would be out of the question for farmers to employ mechanics or to send their implements for repairs, etc. to Mechanical Workshops which are very few in number in India. The cost of these services would moreover be almost prohibitive, considering the present economic condition of our farmers. But before any instruction in mechanics can be given, it is imperative that the elementary education should be spread on as wide a basis as possible in our villages. It may then be feasible for our Departments of Agriculture to prepare and distribute cheap literature on different kinds of farm implements and machinery. In this respect we can follow the excellent example of the United States Department of Agriculture which is rendering great educational service of this nature to American Farmers.

Regarding the manufacture of agricultural machinery in India a good start has already been made by Kirloskar Brothers, Agrico and others, and there is no reason to suppose that our manufacturers will fail to cope with the demand as and when it develops. There is, so far, no firm manufacturing internal combustion engines and tractors, but ploughs, pumps, cane crushers, small electrical motors and generators, small engines, etc. are already being made in India. If the scheme to manufacture motor-cars in India materializes many of our difficulties regarding tractors, etc. would be solved.

It is suggested that students in our Agricultural Colleges should be given more instruction in Civil, Mechanical and Electrical Engineering, as the solution of so many problems in large-scale farming depends on these branches of engineering. This specialized instruction can be arranged in co-operation with engineering colleges or other technical institutions in the neighbourhood. In course of time it may also be desirable and possible to organize special courses in Agricultural Engineering such as those found in the United States of America. Without such specialists it would be difficult to solve our special problems in an effective and satisfactory manner.

The Royal Commission on Agriculture (1928) has examined this problem and stated that the more progressive village artisans should be trained 'to effect repairs, to stock and fit spare parts and to handle successfully the improved types of machinery which are bound sooner or later to be introduced'. Regarding the manner in which the village cultivators might usefully occupy their spare time, they reached the conclusion that 'the chief solution of the problems of the cultivator is intensification and diversification of his agriculture'. This cannot be successfully achieved without the introduction of improved implements and machinery.

The Indian Industrial Commission (1916–18) examined the relation between industries and agriculture, and came to the following conclusions:—

'We consider the improvement of agriculture necessary, not only because it forms the basis on which almost all Indian industries must depend, but also for the further reason that the extension among the people of a knowledge of improved agricultural methods, and, in particular, of the use of power or hand-driven machinery, will benefit agriculturists both by adding to their income and by its educative effect.

It is still strictly true that there is a vast field for improvement in the efficiency of the methods, and still more, of the implements employed by the ryots.

Power-driven machinery may be very largely employed in India in connection with agriculture:—

(1) to lift water for irrigation;

(2) to improve the land by draining low-lying areas, and in certain parts of the country, by deep ploughing;

(3) to prepare crops for the market in the most profitable form. This includes such operations as fibre and oil extraction, wheat grinding, paddy husking, coffee pulping, tea manufacture, and, most important of all, sugarcane crushing...... ;

(4) to prepare materials required in agriculture, such as bone meal for manure, and crushed or chopped cattle food.

Scarcely less important, both as an educative influence on the cultivator and as a means of improving the efficiency of agricultural labour and the quality of the produce, is the provision of hand machinery of improved types, especially of reaping, threshing and winnowing the crops, and the preparation of food and fodder; also of modern plant and implements worked by animal power, to cultivate the land or drive small machines. Further, these will also serve as an easy introduction to the use of power-driven machinery proper.'

This can be accomplished only by close and constant co-operation between agriculturists and engineers.

2. Mr. B. M. Lakshmipathy, Coimbatore.

Agriculture involves production and is therefore influenced directly or indirectly by the application of machinery, electricity and transport methods. The application of engineering to agriculture does not lie so much in the development of large scale individual projects as in the handling of a large number of small matters of considerable aggregate importance and in the development of equipment, principles and practices which can be utilized to advantage by people who are not engineers.

Mr. Lakshmipathy then proceeded to give an exhaustive survey of the position regarding agricultural implements and machinery in the Madras Presidency. He said that European and American conditions do not apply to India, and that he had to start building up from the indigenous implements, keeping in view the low purchasing power of the Indian ryot.

He next referred to the new implements designed at Coimbatore, viz.: (i) improved roll-easy mhote wheel, (2) puddling and trampling implements, and other crop preparing machines like turmeric polisher, groundnut decorticator, etc.

He finally laid stress on the need for the education and training of rural blacksmiths in the departmental agricultural engineering workshops to enable them efficiently to repair the improved implements and machinery.

3. Mr. R. G. Allen, Baroda.

He said that from his long experience of 35 years in India, he was of opinion that the improved implements in India should aim at simplicity of design and multi-purpose utility. They should have as few nuts and bolts as possible and the shear point of the ploughs should be strong to withstand the necessary wear. He gave several instances in which the neglect of the above conditions produced unsatisfactory results.

4. Sir T. Vijayaraghavacharya, Udaipur.

He said that he was of the opinion that large scale mechanization of the agricultural areas should not be blindly adopted as it might lead to unemployment of the rural population.

5. Dr. V. K. Badami, Cuttack.

It is very interesting to note that much advance has been made in the improvement of indigenous agricultural implements and machinery at Coimbatore. Various attempts have been made in different parts of India to improve indigenous implements or to introduce implements supposed to be superior to local ones. These introductions and inventions must have a direct relation to the breeds of cattle available in the Provinces. Many improved implements imported from foreign countries have been a failure for various reasons. In the first instance most of those implements were meant for working with horses. The speed of the horse and its power differ from those of the bullock and the power of the bullocks varies according to different breeds in various provinces. In addition there is a relation between the implements used and the physical character of the soil. The methods of cultivation also have to be considered when implements are imported. Very many attempts have been made to evolve suitable improved implements in this country and some of them have met with great success. The growth of the implements-manufacturing industries, in India, itself, is a great tribute to the exertions so far made.

Many attempts have been also made to introduce power farming. In all these cases it is evident that we have been trying to force on the cultivator implements and machinery that he cannot easily afford to purchase and work. He has his simple all round implements, of a plough or a few very simple drills or hoes, which cost very little. The only big item of expenditure is the iron share. It is, therefore, very difficult to supplant those simple implements which are easily worked by the available cattle power, which is the main source of power available to the farmer. In very many places where implements have been introduced care has not been paid to see whether they are capable of being worked by the local cattle power. When the local cattle are found to be stunted or ill developed, suggestions have been made to improve the breed immediately. These are laudable objects but highly impracticable in actual working. It takes time to improve the breeds and one has to wait for generations to see tangible results. Our main object should be to introduce such improvements as those that would be useful to the cultivator, at the present moment, with his available cattle power. Research should be directed towards the test of the cattle power of the different breeds of cattle in the various provinces and to evolve implements that could be easily worked by them. The cost and the general utility of those implements should be also borne in mind. The simplicity of the implements is a great necessity. After all the power at the farmer's command is the straw and other feeding stuffs found on the farm. These should be converted into power for farming through cattle. We have no rich coal mines nor oil wells nor an inexhaustible supply of fuel for producing power on the farm. Therefore cattle which feed on the straws and the refuse on the farm would be the cultivator's main supply of power in India. And all our researches should be directed to utilize them to the best of our ability.

It has been suggested that wherever there are Agricultural colleges near Engineering Institutes, the agriculturists should spend some of their time in the Engineering sections to imbibe an engineering knowledge to improve the mechanical section of farming in India. I would put the matter, the other way, and say that in all places where there are Agricultural Colleges the engineers should take the trouble to work on the College farms to study their requirements. There is much to be done by the engineer, to help the farmer in India. It is not merely the manufacturing of cheap implements or efficient tools that come within the purview of the engineering. He has also to design cheap machinery for pumping with cattle power, water lifts, and discover ways and means of utilizing water and air power wherever they exist. Sea breeze, monsoon winds, small water falls, rapid water currents and even sunshine are running to waste at the present time. The modern engineer can be of great service to improve agricultural conditions in India to a great extent if he could harness these natural forces. I would, therefore, request all engineers to take an interest in the villagers' life and devote their attention to simple problems and evolve simple machinery, tools and implements which would be within the easy reach of the poor cultivator in the rural parts and help the agriculturist to get out of his slavish rut of life and enable him to march along with his brethren elsewhere on the highway of modern progress.

Mr. N. V. Modak, Bombay, Mr. C. T. Shah, Bombay, and Rao Bahadur N. S. Joshi, Sholapur, also took part in the discussion.

The President in winding up the discussion said that as the pressure on land was increasing rapidly and sufficient food was not available to a large section of the population, the use of heavy machinery might be resorted to for opening up new tracts and for increasing the yield from comparatively large holdings.

XIII. SEX-HORMONES, THEIR CHEMISTRY, PHYSIOLOGY, PHARMACOLOGY AND THERAPY.

(Sections of Physiology, Medical and Veterinary Research, and Chemistry.)

PROF. B. T. KRISHNAN, Madras, presided and opened the discussion.

Opening Remarks.

The study of sex-hormones forms to-day one of the largest and most important fields of Endocrinology. Remarkable development has taken place during the past decade in our knowledge of sex-hormones. The physiologist, the biochemist, the pharmacologist, and the clinician have all contributed to the growth of this knowledge and as a result of this team-work, the sex-hormones have now been isolated in a pure crystalline and a more powerful form and have been standardized in international units; their molecular structure has been elucidated and synthetical preparations have been produced; the varied activity of each sex-hormone has been studied in detail and the knowledge derived has been utilized with beneficial results in the treatment of certain gonadal defects. With all this increased knowledge, there is still a good deal of uncertainty about the exact rôle of sex-hormones in the body. Recent studies have revealed that both male and female sex-hormones are found in each sex and that androgens may show oestrogenic or progesterone like activity. A high androgen content in women is found to be no hindrance to gestation. It was reported recently that a woman with hirsutism and urine androgen content of 14·2 mgs. (average in the male being 9·3 mgs.) had two normal children. Testosterone injected into males is excreted partly as androgen and partly as oestrogen. R. T. Hill transplanted the ovary in the ear of a mouse and obtained a masculine reaction. These observations show that these hormones are not strictly specific.

Testosterone.

Testosterone or its ester testosterone propionate is now in lime light. Its actions on the gonads and accessory sex organs, male and female, on the mammary gland, on the anterior pituitary, on general and skeletal growth, on basal metabolism, on blood sugar, on certain metabolism, on skin vascularity, etc. have all been studied by numerous workers but the results have been conflicting in their nature in many of the cases. Testosterone or its ester has been found to increase the sexual activity of castrated young rats (McCullagh and others) but not in aged senile rats (Hoskins). It has been found to be greatly efficacious in curing cryptorchidism, eunuchoidism, and early hypogonadism or delayed puberty but not in functional or senile impotence (Hoskins, Falco, and others). The root cause of such impotence is possibly a nervous defect rather than a hormonic defect. Testosterone has been found to cause atrophy of the testes through the pituitary when given in small doses, but it causes direct stimulation of the seminiferous tubules with atrophy of Leydig cells when given in large doses (Selye and Friedman). Prostatic hypertrophy is considered to be due to an imbalance of the male and female sex hormones. The male sex hormone counteracts this condition by removing the oedema and improving the tone of the smooth muscle in the prostate (DeJongh, Laqueur, Champy and others).

Though testosterone has definite inhibitory effect on the ovarian cycle and menstruation, it is found to act synergistically with oestrin in increasing the uterine contractions and the size of the uterus and in causing premature opening and growth of the vagina in rats and mice. Growth of mammary gland in normal and gonadectomised male and female rats has also been reported but lactation is prevented or inhibited during puerperium by the administration of testosterone propionate by inunction or intramuscularly.

The factors involved in the testis control of the anterior pituitary require further elucidation. Varied results are being obtained according to the purity of the testis tissue extract. When the extract is freed from oestrogenic material, it is found that the dose required to restore the pituitary to normal condition in gonadectomised rats is five times more than that of the combined hormone. This is suggestive of the rôle of the oestrogenic material in the male. Laqueur and others are of the opinion that a lipoid soluble non-oestrogenic X-substance in the testis has an activating effect on the testosterone and may be responsible for the discrepancies in the observations. The view that there is a second testis hormone elaborated by the germinal epithelium called 'inhibin' which has a restraining effect on the pituitary and thereby an indirect inhibitory influence on the prostatic growth has also been put forward. These views have not yet been confirmed.

Testosterone has also been credited with general effects such as depression of growth by inhibiting the growth hormone of the pituitary (Rubinstein), significant increase in weight by retention of sodium and chlorides, decrease in certain excretion, changes of blood sugar (Zuntz found increase and Lipposo found reduction), early epiphyseal union, increased vascularity and pigmentation of the skin (Edwards), etc., but more intensive work is necessary to establish these results.

Oestrone and Progesterone.

The action of the female sex-hormones on the gonads and accessory sex organs in the pregnant and non-pregnant females is fairly well known. The significance of the presence of a large amount of oestrin in the urine of a pregnant woman, mare, etc. has not yet been clearly understood. One view is that local concentration of oestrin in the placenta, which is now considered a site for production of oestrin during pregnancy only in some animals, is important for the hypertrophy of the uterus and that overflow is a necessary equipment of this (Corner). It is also considered that oestrin prepares the mammary gland for lactation and that breast tissue is most sensitive to oestrogen just as hair follicle is to androgen. Folley and his co-workers have recently shown that oestrogens in small doses stimulate mammary growth and lactation through the anterior pituitary but in large doses inhibit both. According to Westman, the persistence and function of the corpus luteum of pregnancy is dependent on a supply of oestrin and the human corpus luteum contains oestrin in large amount. It has been found that the corpus luteum of hypophysectomized animal has a longer life by the administration of oestrogens (Corner, Robson). That oestrin has no function in pregnancy and therefore is excreted in an inactive form as oestriol glucuronide is another possibility.

It has been found that the urine of non-pregnant oopherectomised women is also oestrogenic. The extra-ovarian origin of oestrin in such cases is a mystery. Extracts of adrenal cortex and anterior pituitary have been found to have oestrogenic activity. It is quite possible that under abnormal conditions adrenal cortex and anterior pituitary may be the source of oestrogen as a compensatory mechanism in the absence of ovaries (Callow and Parkes, 1936).

As in the case of testosterone, various general effects of oestrin have been reported. Inhibition of body growth and weight, higher concentration of inorganic salts in bones, reduction of serum calcium, hyperglycaemia, temporary leucocytosis, etc. have been found by various workers. Premenstrual oedema of the face and hands has been relieved by the administration of emmenin, vaso-motor symptoms of menopause and menstrual headache by oestrogenic therapy. The possible rôle played by the oestrogens in the genesis of cancer requires investigation.

Synthetic stilboestrol which is 3 or 4 times more potent than the natural oestrogen and which could be administered orally or by inunction has been, since its introduction in 1938, used as a very valuable therapeutic agent in clinical practice. As the structure of this substance is different from that of oestrin, the study of its physiological effects in the body is of importance.

Progesterone is highly specific. It shows neither oestrogenic nor androgenic effects and so far no contradictory results have been reported as regards its influence on the gonads and accessory sex organs. Selye, Collip and others have shown that this hormone may be secreted by the placenta. Quantitatively, the output in the urine in the form of sodium pregnandiol glucuronidate gives an indication of the amount available in the body. The presence and the primary activity of oestrin seem to be necessary for the growth and activity of corpus luteum. Progesterone has been used as an effective therapeutic agent in cases of dysmenorrhea, threatened and habitual abortion, eclampsia, and other conditions.

Gonadotropic hormone in pregnancy urine.

The origin and the nature of the activity of the gonadotropic hormone in pregnancy urine have been, since the date of its discovery by Zondek, investigated by various workers. Its chorionic origin and its luteinzing action have been established. It has been found in the urine of males suffering from tumours containing chorionic tissue. It is said that this Anterior Pituitary Like principle acts synergistically with an activating principle in the anterior pituitary, which has not yet been identified, and its action on the ovary is demonstrable only in the presence of the pituitary body and not in immature birds and baby rats, in whom the pituitary is still undeveloped.

Therapeutically, the A.P.L. principle has been found to be of definite value in hypogonadism, azoospermia, and undescended testes, as well as in menorrhagia, metrorrhagia, vomiting of pregnancy, etc. The exact nature of its action in the male is yet to be found. Further work will, it is hoped, reveal its true rôle in the male and in the female.

2. Dr. K. Venkatachalam, Madras.

Venkatachalam and Ratnagiriswaran (*Indian Medical Gazette*) May 1939—found a charcoal adsorbate of the gonadotropic hormones of pregnancy urine to be an effective prophylactic as well as a curative remedy for whooping cough and they successfully treated several cases with the charcoal adsorbate. Investigations were subsequently undertaken to find out whether the adsorbate possesses also some of the other known properties of Antuitrin 'S'. Its usefulness in the treatment of Acne, Hypogenitalism and hastening puberty or maturity (instead of infantilism and delayed puberty), was studied.

The charcoal adsorbate was prepared as follows:—

Pregnancy urine was acidified with glacial acetic acid to a *p*H 5 using bromo-cresol-green as indicator. The urine was centrifuged or filtered if it did not become clear by centrifugalization. To every litre of the clear urine, ten grammes of active charcoal was added and the mixture shaken continuously in a mechanical shaker for eight hours. The *p*H was again adjusted to 5 and the charcoal containing the adsorbed hormones was filtered under suction on a hardened filter paper moistened with 1% acetic acid. It was washed well with water till the wash-water was neutral to litmus and then with alcohol and ether, dried and stored in a vacuum desiccator at a temperature of 15°C.

The activity of the preparation was tested in each case by the usual biological method using 13 days' old, immature, female white rats as the test animals. The rats were selected from a litter in which the animals attained sexual maturity 40 to 50 days from the day of birth. The charcoal adsorbate suspended in distilled water was poured down the throat of the animal by means of a fine pipette. According to their findings, a rat-unit was taken as the minimum amount of the product which produced opening of the vagina and oestrus on the 17th day of age, when administered orally in eight equal doses during four consecutive days. One rat-unit was contained in 10 mg. of the preparation.

The usefulness of this adsorbate in the treatment of acne was tested as follows:—

The adsorbate was prepared with kaolin instead of with charcoal and tested as above for activity. Kaolin adsorbate was preferred in order that an application of this may not cause any discolouration of the skin especially if the pustules happen to be present on the face as are more often the case. A small quantity of this adsorbate was rubbed well over the predominant skin lesions, whether in the form of papules or pustules, for about a minute or two, twice daily and dusted off. Several cases (both males and females) were successfully treated in this way and from the majority of the cases treated it has been found that the course of treatment generally extends over a period of three months, though immediate effects may be produced within a short time after the commencement of the treatment. The course of treatment does not depend upon the nature and extent of the lesions except for the fact that the greater the area affected, the more will be the quantity of the adsorbate required to rub over. It is needless to say that the preparation is cheap and at the same time very effective.

Regarding hypogenitalism, a boy aged about thirteen years who had genital under-development was treated with the charcoal adsorbate. Before treatment was given, the boy was obese, and the size of the external genitalia, viz., the penis and the testicles were very small and undeveloped for his age. The testicles never used to remain stationary in the scrotal sac. They used to migrate up and down the inguinal canal. Five grains of the carbon adsorbate was given three times a day for six months. At the end of this period the penis increased in size, both in length and thickness, the testicles grew bigger and remained stationary in the scrotal sac, and the obesity around the loins, thigh, groins and over the pubis became reduced. He is still under treatment and may require the medicament to be continued for a further period of six months. Here again the cheapness of the charcoal-adsorbate as compared with the cost of Antuitrin 'S' deserves special mention.

To study its properties in the treatment of delayed puberty or infantilism, there were no cases worth studying on. It was therefore thought that, if this possesses the properties to hasten puberty or maturity, its effectiveness in the treatment of delayed puberty gets established without doubt. But, before experimenting this on animals or human beings, it was considered better to test its action first on plants. The common paddy, *Oryza sativa*, N.O. Gramineae, the red onions, *Allium cepa*, N.O. Liliaceae, and a species of the genus, *Phaseolus*, called Karamani in Tamil (probably—*P. calcaratus*) N.O. Leguminoseae, were selected for study. The soil used was a mixture of sand and charcoal adsorbate. 1,000 gms. of this soil contained 980 gms. of prepared sand and 20 gms. of the charcoal adsorbate. The sand used in these experiments was prepared by washing well to get rid of all soluble materials and then subjecting it to thorough frying to ensure destruction of any organic materials that might be present in it. Seeds of paddy, onions and the phaseolus variety were sown in this soil. A bed each of plain prepared sand in the proportion of 1,000 gms. in the cases of paddy and onions, and another containing 980 gms. of prepared sand and 20 gms. of plain charcoal in the case of the phaseolus variety, were used for control tests. The formula of the nutrient fluid used for watering the beds for cultivating the plants was as follows:—

Formula of culture solution.

Potassium nitrate	2 gms.
Sodium chloride	1 ,,
Calcium sulphate	1 ,,
Magnesium sulphate	1 ,,
Calcium phosphate	1 ,,
Ferric chloride	a trace.
Water (Distilled)	2 litres.

Each of the experimental beds was watered with 100 c.c. of this fluid once daily. The growth of paddy in the test bed was very much hastened. Its maturation, as evidenced by the flowering of the plant, took place by the 45th day in the test bed while the plants in the control bed, under identical conditions, showed no signs of maturation.

This establishes the fact that the charcoal adsorbate containing the hormones does possess the property of hastening the growth and maturation of plants. This could be applied to animals also and experiments on this line are in progress.

Photos of a cured case of acne (before and after treatment), of an improved case of hypogenitalism (before and after treatment), and control as well as test beds of paddy, onions and phaseolus variety were demonstrated.

3. Mr. H. D. Naronha, Ahmedabad.

The speaker raised the question as to which of the hormones was responsible for the quicker rate of growth and whether the results observed were not due to other substances adsorbed or to the adsorbate itself.

4. Dr. B. B. Dikshit, Bombay.

He remarked that in using kaolin or charcoal as adsorbate, all the hormones in the urine may be adsorbed, and therefore a patient treated for undeveloped testes may receive both anterior pituitary hormone and oestrin. In such a case oestrin may do considerable harm.

5. Lt.-Col. S. S. Sokhey, Bombay.

He stressed the necessity of specifying the different hormones involved in Dr. Venkatachalam's experiments. He drew attention to Zondek's work who had originally suggested the use of oestrin for the treatment of acne in girls; he had pointed out that oestrin, if used for male patients, would lead to impotence. Lt.-Col. Sokhey feared that the hormone which Dr. Venkatachalam was using was a mixture of hormones of which oestrin is one.

6. Dr. K. Venkatachalam, Madras.

In reply he said that his experiments definitely showed that the charcoal alone has not contributed to the rate of growth. He agreed with Dr. Dikshit and Dr. Naronha that all urinary hormones might be contained in the adsorbate. His object was to find out whether the charcoal adsorbate, found effective in the treatment of whooping cough, was also effective in the treatment of acne, hypogenitalism, etc. The results of my experiments established such an efficacy of the adsorbate and the preparation compared very favourably with Antuitrin 'S'. It would be certainly very interesting if other workers would endeavour to find out what other substances contained in the adsorbate would also produce such sex stimulating and growth promoting effects.

As regards the question raised by Lt.-Col. Sokhey and Dr. Dikshit that oestrin used in male patients might lead to impotence, he wanted to point out that his experience in treating, with the adsorbate, several cases of acne and hypogenitalism in males with no harmful effects such as impotency, etc., has been that this adsorbate can be safely used in such cases. Moreover, had oestrin been active in the adsorbate, the development of male sex organs observed in his cases would not have occurred but on the other hand signs of feminization ought to have been evident. Further the charcoal adsorbate prepared from Stallions' urine known to contain oestrogenic hormones has been observed to produce all the effects of oestrin in adult female patients whereas this adsorbate (i.e. the one made from pregnancy urine) has never been found to produce such effects in females.

The results obtained in his experiments showed that the active hormones in the charcoal adsorbate are the gonadotropic hormones of the pregnancy urine and not oestrin.

Concluding Remarks.

The Chairman in winding up the discussion emphasized the importance of the study of the rôle of sex hormones in the body. He thanked Dr. K. Venkatachalam for demonstrating the interesting results he obtained with the charcoal adsorbate of pregnancy urine. He hoped that the discussion on this subject would arouse sufficient interest among the members present and serve as an impetus for further work.

XIV. CO-EDUCATION.

(Section of Psychology and Educational Science.)

Dr. G. Pal, Calcutta, presided.

1. Mr. J. M. Sen, Krishnagar.

A thorough consideration of the subject would require an excursion into the general theory of education during the period of adolescence of boys and girls. This however is not possible in a symposium. Hence the present discussion of adolescent education of both boys and girls in a mixed institution must assume that the point of view of modern pedagogy is familiar, and it must limit itself as far as practicable to the specific features falling within the age limits of adolescence.

It is realized that great difficulties attend the successful carrying-through of a psychological survey of the adolescent mind chiefly due to reticence and religious bias. In spite of the difficulties the following characteristics of the adolescent mind are however noticed:—

(i) The Indian boy and girl are very markedly less interested in, and inspired by, their immediate environment than are the Western boy and girl.

(ii) The interest which *religious characters* have for the young girls in India is many times greater than that which they have for the western girls. But a very small proportion of Indian girls choose women as their ideal; e.g. very few girls nowadays choose Sita as their ideal.

(iii) The tendency to 'hero-worship' is specially marked between the ages of 15 and 18, and the girls often choose men as their heroes and if they can find a model (although imperfect) among the young men of the same institution they try to exert an influence over the mind of the latter.

(iv) The effect of the Indian communal system in family, caste and village seems to be a tendency to look beyond the immediate environment in hero-worship, and an early stimulus to find ideals of action and character away from the home-circle in the spheres of education and politics. This accounts for the activities of young students (men and women) in outside organizations like the Students Federation and not in the organizations conducted by their own educational institutions.

(v) The intellectual interest shows two points of maximum development, at 13 and 17.

(vi) The ethical interest is high up to 13, and then declines markedly but rises again, showing its maximum development at 18.

(vii) Altruism seems scarcely to appear as a motive before 16 but after that occurs with some frequency.

(viii) Both patriotism and bravery show marked increase in strength as factors conditioning hero-worship about the years 16 and 18. Hence the young men and women often look to authorities outside their educational institutions for guidance.

Co-education as a method is still a matter of controversy, and like all other questions in this unfortunate position, is subject to distortion by supporters and opponents alike. The partisans of mixed schools are 'whole hoggers' regarding co-education, and would keep boys and girls together and under the same regime through all stages of growth. On the other hand, the opposite group maintains that co-education has proved a failure. Some investigators have made out a good case in favour of co-education. While others supported by the views of some American school-masters maintain that the system is bad and therefore should be discarded. The objection usually advanced that boys incline towards effiminacy remains at the stage of assertion and 'not proved'. On the other hand, it is admitted by all that behaviour is better, and that, on the whole there is a less tendency towards a weakly sentimentalism regarding the opposite sex.

The materials of education are daily becoming the same for girls as for boys. The present movement in woman's education is contemporaneous with the general endeavour on the part of woman to free herself from her old absurdly limited sphere. She wants to follow the way established by man and for man. Out of this has come the so-called competition of woman in man's pursuits, e.g. in the professions of law, medicine, teaching and even industries. But as her education modelled on that of man, prepares for nothing else, in so far as it prepares for anything, the result is no more than to be expected. The same curriculum and methods of instruction are in force and the same examination at the end. Why then blame co-education ? Co-education will make competition keener without making one sex blush or feel humiliated at the success of the other sex. As a matter of fact, in secondary schools and colleges where boys and girls are taught together brilliant results achieved by the girl students are not much taken notice of by the boys of the same class. Each group considers the matter as one of competition and a preparation for life. From this standpoint the psychological effect of co-education must be considered as healthy.

2. Miss Shanta Chaudhuri, Calcutta.

Effects (emotional and intellectual) on the mind of students with special reference to that of female students.

Problems relating to co-education do not usually arise before the age of ten. In kindergarten schools good results are obtained from mixed classes—the age of the students there varies from ten to twelve. There, the school environment is as congenial to the students as is their respective homes comprising brothers, sisters and others. But the condition differs when the children attain puberty. It is at this stage, that co-educational problems, such as, whether the presence of opposite sex influences in any way the intellectual or emotional development of an individual really, do arise.

This paper attempts to discuss these problems specially with reference to girl students. The writer has prepared a limited questionnaire for this purpose and has collected valuable materials from several girls belonging to different schools and colleges.

3. Miss P. Das, Calcutta.

Effects of Co-education on Emotion.

(1) Meaning of Co-education.

(2) Co-education and its effects:—

(a) *Co-education as an intellectual impetus*:—Healthy rivalry and wider outlook; Courage of Conviction; Discussion and exchange of ideas—more 'give and take'; Clearer conception and better expression.

(b) *Effects of Co-education on emotions*:—The rôle of co-education situation on emotional maturity of girls; Decrease of sensitivity; Preparation for later emotional adjustment; Emotional disillusionment; Emotional education—special effect on sex-development.

(3) Certain practical suggestions.

4. Dr. (Miss) K. H. Cama, Bombay.

Miss Cama strongly supported the cause of co-education at all stages of education. She said it was healthy and beneficial to both the sexes to be educated together from the earliest to the highest stages of education, considering it from biological, endocrinological and psychological points of view. Conflicts arising out of co-education, pointed out by the opponents of co-education, are not half as serious and harmful as those arising out of the segregation of the sexes. Normal heterosexual love emerging from co-education and leading to marriage is far better than the homosexual love which arises in institutions deprived of co-education and hence of the opportunities of the sexes coming in contact. She pointed out that Indian students who had been educated and brought up in segregated institutions and homes often behaved like lions let loose from cages when they happened to go out to foreign countries, where there was freedom of mixing with the members of the opposite sex, and made themselves objects of ridicule.

5. Mr. S. Jalota, Bombay.

The influence of a mixed class on the attitude of a teacher.

For the purpose of this discussion, I will take the normal attitude of the teacher to be a complex of dispositions to attract attention and interest of the students in his subject; an alertness to discover the development and flagging of the students' interest.

The proportion of the sexes plays a large part in influencing the attitude of the teacher. Generally speaking, if the proportion is very small, then the strain is more pronounced than is the case if the proportion is fair. I must add however that mathematical ideas of ratio and proportion are not of much use for physiological calculation in such case, e.g. eight girl students in a class of 80, are less of strain, than 1 in 10, or even than 1 in 5. Under modern Indian conditions 20% of mixture would be a fair proportion.

Further, even in mixed classes the sexes are often segregated. The girls, being in a minority, are placed in one corner, while the boys are scattered all over the rooms. This segregation of the sexes is also responsible for emphasizing the mixed character of the class. It also provides an opportunity for some sensitive teachers to ignore the girls' presence, and contrasts with the behaviour of others, who thus pay marked attention to the ladies' corner. I think the technique of a teacher requires that he manoeuvre in all directions in front of the board. Thus a teacher, who has perfected the habit of distributing the direction of his gaze from the right side to the left and back, in a regular robot manner, stands the best chance of keeping undiscovered his own eccentricities.

Many teachers take advantage of the girls' corner in asking questions of them, when they fail to get a suitable answer from the boys' benches. Thus they try to shame one group in contrast with the other.

The ladies having a reserved corner often form the habit of entering the class immediately before or after the entry of the lecturers. Their exit also is immediately before or after that of the lecturer. In those cases, where the girls enter immediately in the wake of the lecturer, and get out immediately before the lecturer, the lecturer feels as if he is filling a protective rôle towards the girl students. In the case of bachelor lecturers, unused to mixed social gatherings, such a situation is acutely felt. And, if it is suspected that any girl is being 'persecuted', then such a protective rôle may easily lead to officious conduct that does provoke some boy-students to regard the said lecturer as a rival with an unfair advantage.

In the case of indiscipline in the class, the ladies' corner is expected to pay due courtesy to the lecturer and maintain due decorum during the interval of indiscipline. However, when the girls take a hand in creating indiscipline, or take the lead in expressing disregard of the conventional class-room order, then a sensitive male teacher may feel as if he is being unexpectedly tricked and his vanity wounded in a peculiarly weak spot.

6. Mr. Anathnath Basu, Calcutta.

Influence of a Mixed Class on the attitude of the Teacher.

The problem can only be studied in reference to the social background and cultural heritage of the community that supplies both the teacher and the pupils forming the subject of the enquiry. In a community in which boys and girls grow up in bracing comradeship with one another the problem is not much different from the eternal one of selective attraction between the sexes which makes a mother more attached to her sons than to her daughters and a father display a marked partiality for his daughters in preference to his sons. Complications arise when the environment is the result of a social order which is based on the idea of segregation between the sexes.

Supposing the pupils of a mixed class to be perfectly normal in their relationships the attitude of the teacher will depend on his age, sex and emotional maturity. Young teachers both male and female are likely to display a marked partiality for pupils of the opposite sex. Old teachers are liable to ignore the sex-differences in his pupil. An emotionally ill-adjusted teacher is likely to accentuate the sex-differences in his or her pupils in defence of his or her own unbalanced conduct towards them.

A teacher's attitude towards a mixed class is qualified to a marked degree by the age-group to which the pupils belong.

A common noticeable feature in a mixed class of adolescent pupils is that the boys as well as the teacher, specially if the latter happens to be young have a tendency to show off to win the admiration of the girl pupils. Within certain limits such showing off leads to healthy competition but if the teacher himself succumbs to it and fails to keep it within the bounds of decency, it is likely to affect the girls and become a fruitful source of indiscipline among the boys.

Young men teachers in charge of adolescent pupils sometimes consciously and more often unconsciously develop tender sentiments towards their girl pupils and the least expression of such sentiments in or outside the class arouses very keen rivalry among the girl pupils. Sometimes it also so happens that the teacher and some boys become rivals for the love and admiration of a particular girl. In either case the normal equilibrium in the class tends to be disturbed to the cost of intellectual and emotional development of the pupils.

With the attitude of teachers to mixed classes is intimately connected the problem of discipline. The presence of girls often engenders a spirit of bravado, which may challenge the leadership of the teacher and thereby create a disturbing situation. It must however be admitted that the presence of the opposite sex sometimes act as an intellectual spur and also may refine the social behaviour of the pupils provided however the teacher gives the proper lead.

The foregoing remarks in respect of the influence of a mixed class on the attitude of the teacher are based on personal experience of such classes both in India and abroad. While in Europe and the U.S.A. any expression of emotional attachment between the teacher and the taught is passed unnoticed by the elders, it more often than not sets up a tumultous commotion in the community here. Mixed classes specially of adolescent pupils are still rarity in this country. Then again the few schools which have such classes usually draw their pupils from homes which combine the traditions of the East with those of the West as far as social intercourse between the sexes is concerned. Even in the U.S.A. where mixed classes are the rule there have been few scientific investigations into the educational implications of the influence of a mixed class on the attitude of the teacher. Until more reliable data are available it is difficult to pronounce judgment on a mixed class from the educator's point of view. This is all the more difficult in this country where lack of scientific interest and social conditions stand in the way of studying and collecting reliable data based on frank statements of either teachers or their pupils.

7. DR. INDRA SEN, Delhi.

Co-education treated from the social standpoint.

The problem of co-education may primarily be attacked scientifically by considering the basic human nature, as bearing upon the subject of sex relations. We will then ask, how does co-education affect the normal and healthy growth of personality? But from the social standpoint the question will be: How is co-education going to affect the cultural equilibrium of particular society?

Sex is an important drive of human nature. Civilization has since its early beginnings sought to put strong regulative check upon it. But the progressive subordination of instinct to reason, as in the individual so in the society, is a most delicate task. Repression is bad but free life is no possible alternative.

Freud gives the correct guide in the educational maxim propounded by him in his new lectures, viz., repression is necessary, but we should know how much to repress at a particular stage and by what means.

Social complications are bound to arise from co-education, if it is adopted in a society in disregard of its present cultural conditions. A slow change in that direction is advisable.

On a total consideration of a society's present stand, it can be possible to determine the measure and manner of co-education possible of practical achievement.

A measure of co-education introduced in excess of that standard is bound to lead to undue licence.

Co-education involves a social ideology based on the ideas of equality between the sexes and individual's freedom. But 'equality' and 'freedom' are deceptive labels.

8. MR. K. C. MUKHERJI, Dacca.

Co-education as studied from the social point of view.

Havelock Ellis quotes from a report about East Germany that it is not surprising that many believe that after sixteen no girl is a virgin. Dr. Hermann Ferier states that 'the wholesale entrance of women into politics must inevitably introduce complications owing to the conduct of different sexes . . . . . The boys and girls tell lies each other and pass up work in some one else's name; pugnacity is aroused in the presence of girls and discipline is audaciously rejected, because it is humiliating. Time is wasted in philandering'. Co-education is to face these startling facts of sex life.

Miss Shinn concludes on statistical basis that the ultimate probability of a college woman's marriage is below 55% as against 90% for other women. Does familiarity bring a little disenchantment in place of the mystic attraction of the other sex? Herbert Spencer stated that 'absolute or relative infertility is generally produced in women by mental labour carried to excess'. Is then the same ideal of education desirable for both sexes?

Co-education generally means far more assimilation by girls of boys' ways and work than conversely. Prof. Small observes that to train women to compete with men is like poison administered as a medicine. The divergence of the sexes is a marked characteristic of progression among highly civilized races. But co-education, woman's suffrage, etc., tends to approximate the ideals. Such approximation will tend to vivify women and feminize men and may inaugurate retrogressive evolution or at least will not belong to the progressive evolution of mankind.

The social structure of the Indian people shows in addition large illiteracy, strong conservatism, early child marriage and caste restriction, unlimited restraints of widowhood, the prevalence of Purdah system, acute ill-feelings among persons of different communities, etc., and, in the background, the conservative spirit of Manu's injunction that मात्रा स्वस्रा दुहित्रा वा न विविक्तासनो भवेत् । So to this prevailing order of the Indian Culture co-education will prove radical and may subsist not as an element of it but as a parasite on the sex-impulse. The genuine culture should be inherently harmonious, balanced, self-satisfactory and not a hybrid of contradictory patches. Social life is not a sum of abstractly desirable ends; it is more an internal growth. So mere sophistication of efficiency, social or economic, is not what is socially wholesome.

9. Dr. I. Latif, Lahore.

Complication of Co-education.

An attempt was made, in this paper, to discuss certain anomalies in the emotional development of boys and girls. Certain complications arising from factors existing in Indian social environments were also discussed. No sound co-educational scheme could afford to ignore these factors. Two clinical cases were presented to illustrate the main thesis.

10. Mr. Pars Ram, Lahore.

Complications of Co-education.

(1) Recent inquiries into the friendships of young people of the college-going age show that these friendships are essentially neurotic in character. The friend chosen is just a trigger to release, castration anxiety, infantile oral and anal aggression, and oedipus ambivalence. In other words, these friendships release the infantile conflicts and present a challenge to the stability of Ego. When friendship relation obtains between a young man and a young woman, it may stimulate infantile, the father-daughter or the mother-son relationship. One of the tasks of education is to create in the educand a wholesome toleration of the intensity and frustration of the impulses which cannot be gratified at the reality plane. Now friendship between boys and girls may so gratify some of the infantile cravings that both the boys and the girls may fail to acquire the useful habit of tolerating their impulses. In this sense co-education fails to train the educand to face the reality situation. Again the co-education situation increases the intra-personal bi-sexual (feminine-masculine) conflict in the young people, particularly so in girls. Girls tend to be a little boyish and boys a little girlish. This fact again operates against the stability of Ego and prolongs the period of stress and strain for a comparatively longer period. Some people are not able to overcome this conflict even in the thirties and forties of their lives.

(2) Latency period presents a different kind of danger. Here the hatred of the boys for girls is manifest. Aggression and the bullying of girls by little boys is a common occurrence in co-education primary schools. These aggressions if stabilized may create a permanent bullying

attitude in the boy and an inferiority feeling in the girl. At this stage boys show a clear hatred for the girls without any hesitation whatsoever.

These complications should not suggest that co-education is undesirable. Living at a higher plane brings with it its complications and conflicts which have to be faced and solved. The function of education is to enable the boys and girls to see through their own conflict so that the mere insight serves to bring a stable Ego in them. Hence personal guidance should be a necessary part of education in a co-educating institution.

11. MR. M. Z. ABDIN, Madhubani, Behar.

The Stage at which Co-education ought to be introduced.

The proper stage for the introduction of co-education is the Primary stage:—

(1) Psychological reasons—Loss of the glamour of sex due to growing up together.
(2) Academic reasons.
(3) Its advantages over the Secondary stage and the University stage.

The introduction of co-education at the Secondary stage, for the first time, may prove emotionally and intellectually harmful. The transition from the Secondary stage to the University stage will be smooth for those boys and girls who have been co-educated from the Primary stage.

The main theme of the discussion is that the Primary stage is the proper one for the introduction of co-education. It ought to be continued throughout the Secondary and the University stages.

12. MR. S. N. MUKHERJEE, Baroda.

I. Historical background.

Co-education is not of recent origin. Even up to the 4th century A.D. boys and girls up to the age of 16 or 17 used to attend monastery schools together. Segregated education perhaps became a recognized system during the mediaeval times.

II. Main considerations.

The subject may be considered in three different sections, as referring to Primary, Secondary and University stages.

1. *Primary Stage.*

In elementary schools, specially in rural communities, co-education exists naturally. For children up to ten, there is not much of differences of opinion, because till then differentiations between both the sexes are hardly perceptible.

2. *Secondary Stage.* (Very debatable position.)

A. Arguments for co-education:—

1. Social.

Training for citizenship. An imitation of home at school. Better type of mutual understanding. Each sex gains advantage from the other.

2. Economic.

Co-education is a cheap business.

3. Mutual benefits.

In co-educational institutions, girls are keener and more broad-minded—while boys are more refined. Lessons are brighter.

B. Arguments against co-education:—

1. Instinctive desires for both the sexes to remain separate.
2. Physiological growth.

Adolescence dawns a year or two earlier in girls than in boys. Girls require more of rest and less of emotional excitement during this stage.

3. Psychological growth.

Interests of boys and girls are quite divergent. Girls are easily fatigued. Competition with boys and a overloaded curricula are not desirable for girls. Need of different technique.

4. Sociological.

The need of both the sexes are quite different. Need of separate subjects with separate teachers. Thus co-education becomes quite nominal.

5. Moral. (Often there are instances of undesirable friendships.)
6. Other considerations.

In co-educational institutions, needs of girls are not properly looked after, and boys dominate.

3. *University Stage.*

Many arguments for and against co-education of the Secondary stage are also applicable here. But popular feeling is not too much against co-education in this particular stage. Courses of study, specially suited for women as optional groups, are being organized by various Indian universities.

III. Conclusion.

There is not much objection against co-education in the Primary and University stages. But co-education is not desirable in the Secondary stage, because the children of both the sexes are so very different and they pass under a critical stage of growth.

13. Mrs. Kusum V. Thakore, Baroda.

14. Dr. J. M. Kumarappa, Bombay.

XV. PSYCHOLOGICAL APPROACH TO AESTHETICS.

(Section of Psychology and Educational Science.)

Dr. G. Pal, Calcutta, presided.

1. Mr. N. S. N. Sastry, Mysore.

(1) The problem of Aesthetics demands (by its essential nature and importance), a solution at the hands of the Philosophers and Psychologists alike. The problem has got far-reaching significance to the philosopher

inasmuch as its solution can afford a recognizable ultimate value—the value of beauty. The experience of beauty is common to all and can profoundly influence the behaviour of man. The Psychologist feels called upon to investigate the nature and significance of this experience.

(2) There have been attempts at solving the problem, ever since civilization began its growth. The early attempts—in some cases are exceedingly interesting and it is worth while to acquaint ourselves with such attempts.

Nearly two thousand years ago Bharata enunciated his *Rasa* aphorism which still finds favour among the rhetoricians in India. The attempt at the solution, here is from the point of view of art-beauty. The solution suggested is an explanation of aesthetic pleasure with passing reference to the psychological characteristics involved.

In the West, the earliest attempt is that of Socretes, Plato and Aristotle. This was followed by Baumgarteei, Kant, Hegel, Hogarth, Binke and others and gave rise to aesthetic theories like Absolutism. Formalism, Imitation, Subjectivism, etc. The predominating philosophical tendencies of the day are reflected in the theories. Moral and ethical considerations seem to colour the theories in some cases.

Both the western and eastern attempts in the past are essentially either literary or philosophic.

(3) The present status of the problem can be best gauged by taking into consideration the contribution of modern writers. Bosanquet and Expressionism; Blake and intelligent purpose; Bell and significant form; Croce and free-expression; the theory of Empathy; Psychic distance; the Pscyho-analysts and their explanations; these represent some of the modern attempts. These are sufficient to lead one to bewildering confusion.

Experimental Psychologists have also tried to solve the problem. A survey of the work of such modern workers like Bulough, Myers, Valentine, Bully, Gorden, Feasey, Puffer, Seashore and others, shows that attempts are on the right lines but much of the result is negative in character. But notable attempts are there which have solved some of the points for which we wanted answers. Yet, doubtless much work has to be done.

(4) By its very nature, both in regard to methods of study and scope Psychology seems to be best fitted to solve the problem. Unhampered by philosophic or other obligations psychology can take an unbiassed interest in the task. Its methods, i.e. of introspection and experimentation, can be relied upon to give scientific truth regarding aesthetic experience and its nature. Survey of modern experimental work warrants such a hopeful attitude.

(5) These psychological attempts also reveal the fact that the proper approach to the problem is the psychological one. Suggested methods of measurement of appreciation; scales; studies in the appreciation of such objects of aesthetic significance like music, painting, poetry—all these landmarks in the history of modern psychological attempts—tempt one to pause and take stock of the work done. The evaluation of all these attempts strengthens us in our belief that psychology can help us here.

(6) The sum total of all the work done so far leaves much to be desired. Will the final word about aesthetics be that of the psychologists? Modern attempts do not always strengthen us in that hope. Modification and readjustment seem to be necessary. A suggested symposium and consequent recommendations might help more. Otherwise we may have to ask modern experimental aesthetics the question—Quo Vadis?

2. Dr. B. L. Atreya, Benares.

Psychological factors determining Aesthetic Judgments.

In our opinion beauty is a unique quality, *sui generis* in nature, which inheres neither in an object nor in the percipient but in a particular relation between them. It is an emergent attribute pertaining to the total situation in which the subject and object are placed in relation to each other, and quite a large number of factors operate in it. The aesthetic experience on which our aesthetic judgments are finally based is characterized by spontaneous attention, minimum tension, maximum satisfaction and intense agreeableness. We have to seek for those psychological factors which bring about these. Some of the factors involved in the situation are pointed out and discussed here.

(1) *The sensory material.*—Very little is known as to why certain sensory qualities and certain intensities of them are apprehended as beautiful and others as indifferent or ugly.

(2) *The form in which the sensory material is arranged.*—The form is often more important than the material from the aesthetic point of view. Symmetry, proportion, pattern, rhyme, rhythm and assonance enhance the feeling of unity in diversity which is an essential mark of beauty. Remark on the Golden Section.

(3) *Motor adaptation and organic sensations* which accompany all perception also go to a great extent in colouring our aesthetic appreciation.

(4) *The imaginal contents of the percept.*—The aesthetic value of a percept is also affected by the relation the revived images, which form a part and parcel of the object, and revived memories of all sorts of the past relations of the subject to the object, bear to the percipient. They often alter the aesthetic value of the sensory material and the form in which the percept is cast.

(5) *The Hedonic tone of the experience.*—The core of aesthetic appreciation is its pleasant hedonic tone. The object apprehended as beautiful is one which appears to us to be a stable and common source of pleasure. It is a psychological mistake to think that the hedonic tone depends entirely upon the object. It depends upon many other physiological, subjective and personal factors.

(6) *Expression of meaning.*—The greatness of an artist consists in his ability to express the greatest amount of meaning through the least amount of material and through the most commonplace forms. Croce's view. So in nature, the more an object means to us the more beautiful it appears. The human and animal forms appear beautiful to us in proportion as they express thoughts, feelings and emotions.

(7) *Empathy, Projection, Hallucination and Delusion.*—The meaning we read in things is often of our own making. We project our own ideas, feelings, emotions and wishes on the object. To a great extent beauty is a mask of our own making which we unconsciously place upon the objects.

(8) *Sexual impulse.*—Sexual impulse plays a great rôle in aesthetic appreciation, and according to some writers like Santayana and Durant, it is the basic factor. The proof of this contention is that woman is the primary object of beauty for man and in her those parts and characters are the centres and marks of beauty which are primarily and secondarily concerned with sex.

(9) *Other Instinctive desires.*—Other desires rooted in other instincts, parental, creative, gregarious, inquisitive, possessive and even hunger and thirst, etc., when very strong and unsatisfied for a long time may also lend as much charm to objects as the sexual does.

(10) *Psychic distance between the subject and the object.*—Distance both physical and psychic is essential for aesthetic enjoyment of the object and it lends charm to it.

(11) *Habituation, Novelty and Change.*—Familiarity modifies and takes away the charm and beauty of things and it also modifies and lessens their ugliness. Novelty and change are very essential for beauty. Magha's view.

(12) *Other influences.*—The family, the community, the race, the political party, the religious fraternity, friendship, heredity, maturation, etc., all exercise their influence on our aesthetic judgments consciously or unconsciously.

3. Mr. R. M. Loomba, Delhi.

Influence of philosophical studies of aesthetics on present-day psychological outlook.

(1) The psychological approach to aesthetics arose as the psychologists' revolt against philosophical tendencies in aesthetics.

(2) The philosophical aestheticians also aligned themselves with this revolt either by recognizing basic key problems as fundamentally psychological or by adopting a dogmatic position on clearly formulated questions that admit of an answer only after psychological investigation.

(3) Nevertheless the psychological approach is beholden to philosophical studies in several ways. For one, it is out of philosophical studies that the psychological approach has arisen.

(4) Philosophical studies have suggested major problems for psychological aesthetics.

(5) It is philosophical studies that have supplied the basic concepts for the psychological approach to work with, which, despite the psychologists' repudiation of philosophy, continue to exercise their influence on the psychological approach to aesthetics.

(6) Particularly is the influence of philosophical studies manifest in the psychological approach to aesthetics developed by the psychoanalytical school.

(7) The psychological approach to aesthetics owes more debt to philosophical studies than it is yet conscious of. For the latter has left to it conceptions like those of the immediacy, freedom, delight and creation with an autonomous value of its own, so characteristic of aesthetic experience, which the psychological approach has yet to take account of, investigate and elaborate.

(8) There are signs of psychological aesthetics staging a return back to philosophy.

4. Dr. S. C. Mitra, Calcutta.

History of Experimental work on Aesthetics.

Time is not ripe yet for writing history of experimental work on aesthetics—Non-scientific interest in aesthetics is still dominant—That there is a psychological factor is realized now, but no clear idea about the nature of it—Fechner initiated experimental studies, but he himself was more interested in theoretical discussions—Subsequent works dealt either with one or other factor selected at random—Some stressed 'heaviness' of colours, others 'proportion' of lines and so on—Sasthry's studies—These works raised other questions of theoretical interest—Is aesthetic feeling different from feeling of pleasure ?—Gestalt psychology with its emphasis on totality is clouding the issue again as regards analysis of the factors in aesthetic perception—Tendency of going back on ultimate questions—Some hypothesis are of course necessary—Dr. Bose's suggestions have been substantiated to some extent, but crucial tests are still necessary.

Aesthetic appreciation and aesthetic creation—Two sides of the problem—Both should be studied—It is too early as yet to narrow down the problem to the investigation of one or other item only. The enormous influence of the unconscious both in appreciation as also in creation has not been properly taken into account as yet—Some suggestions have been made in this paper about future experiments.

5. Mr. P. S. Naidu, Annamalai.

The Hormic approach to Aesthetics.

A psychological approach to aesthetics must, deal with the subjective more than the objective aspect of the aesthetic situation. Many psychologists have not appreciated to the full the significance and value of this subjective approach. Hence they have failed to produce any satisfactory result by their analyses.

The psychologist, in analysing aesthetic experience, must single out and distinguish between the urge to the creation of an aesthetic object and the urge to the enjoyment of the object thus created. In other words, our analyses must show, as far as possible, how the mind of the great artist works when it creates a masterpiece, and how the mind of the appreciative critic works in understanding and evaluating that masterpiece.

According to McDougall's hormic psychology, emotions, and sentiments must express themselves in some suitable form. For the vast majority of human beings this expression takes the form of ordinary behaviour of daily life. The ordinary channels of expression are utterly inadequate for the great and sublime sentiments of the creative *genius* struggling for expression. It is then that the mind of the artist strikes out an entirely new channel and creates a supremely valuable and unique aesthetic object. Great art which is also true art, whether it be Music, Painting, Sculpture, Architecture, Drama, Dance or Poetry is, then the fitting expression of the Supreme *Sentiment* of the Artist. Art is the concrete embodiment of the noblest 'sentiments' of the human mind.

The appeal of art, even of great art, is not universal. In the presence of the finest types of classical music or painting many persons of the present generation are unmoved and feel quite cold and unresponsive. Art is not democratic; there is something forbiddingly aristocratic about it. Hormic psychology has a ready explanation to offer for this fact.

Art is the 'expression' of an exalted 'sentiment'. And unless a 'sentiment' approximating in some degree at least to the great sentiment in the mind of the creative artist which gave birth to the aesthetic object, is present in the mental structure of the perceiver it will leave him cold and unmoved. The appeal of great and true art is only to *Sahṛdayas*.

The hormic approach to aesthetics thus enables us to analyse and understand the 'urge' which creates Fine Art, and the 'urge' which makes the enjoyment of such art possible.

6. Mr. S. K. Bose, Calcutta.

Aesthetic feeling differing from aesthetic preference.

The confusion between aesthetic feeling and aesthetic preference is too common. That which is liked or preferred is not aesthetically pleasant. We find a tragic drama sad; that is a question of feeling. But we may like it despite its tragic character; that is an instance of preference. The feeling of pleasantness or unpleasantness outlives personal factors of association or cultural influence. It goes deeper than that. The so-called warm colours or joyous sounds have the stamp of immediacy and universality due to a deep-rooted natural basis. A few ingenuous theories have been advanced by the biologist, the psycho-analyst and the philosopher, but the laboratory psychologist has yet to give the results of his findings. The works of Valentine, Bullough, Huber, Allesch and others present conflicting data. The artists too differ in their opinions. The problem calls for thorough investigation in the laboratory by highly trained psychologists. The objects rousing aesthetically pleasant feeling seem to be intrinsically beloved and there appears a close kinship between the pleasant character of the object outside and the pleasant character of the emotion within. Genuine aesthetic appreciation is a matter of inner feeling and not dependent upon the knowledge of harmony or the like.

7. Mr. R. Ghose, Calcutta.

Unconscious determinants of Aesthetics.

Aesthetics—looked from the point of view of unconscious psychology—have been found to depend mostly on unconscious complexes. Appreciation as also creation of art are based to a large extent on repressed unconscious impulses. Art creations are nothing but projections of artists' unconscious desires. Artistic tastes are in most cases dependent on unconscious associations that find symbolic expressions in conscious aesthetic preference.

Aesthetic couches in its formation various defence mechanisms. It holds before us a picture of compromise between the Ego and the Super-Ego equilibrating the demands of the Id. An aesthete resembles an obsessional in his method of meeting anxiety-situations. An individual seeking emancipation in aesthetics has an Ego which was outlined and constructed at the anal stage of its development. In aesthetic creations one finds alternating states of manic exultations and psychotic depressions. An aesthetic object is a source of relieving stimulations tending to afford a security against the eventuality of an anxiety. An aesthetic object embodies in itself earlier figures (incorporated in the Ego at the anal stage of its development and later elaborated by the primacy of anal feelings) detaching themselves from corresponding emotional endowments in child life and promising a possibility of enjoyment.

Aesthetic appreciation includes a saving of psychical energy (an economy of psychic expenditure) by making a detour in the psychic territory without trespassing into the repressed frontiers of the mind. Aesthetics, therefore, is a gilt-edged investment from the standpoint of civilization and society, promising a bountiful return of human happiness.

8. Mr. K. D. Ghose, Dacca.

Aesthetic Taste and Education.

What is aesthetic taste—Such training a part of the educational programme since Vedic and Greek times—A historical retrospect—The renaissance in the 19th century partly a reaction against the conditions ushered in by the Industrial Revolution—Ruskin and Morris and their plea for aesthetics in the school curriculum—The other side of the Industrial changes—Increased leisure—The problem of utilization of this leisure—Workers' Clubs in the West—The need of such tastes in the modern industrial world—What is aesthetic appreciation—Croce's view—The means of cultivation of aesthetic tastes and feelings—A matter of training—One takes away as much as one brings—The English philosopher Hutchison's view—The formation of such tastes a solution of the many difficult problems connected with the human personality—The springs of creation released.

9. Mr. P. K. Chhatra, Baroda.

A Case for Aesthetics in Indian Schools.

Conflict between the ideals of schools and those of the adult world—present social and political atmosphere round the school-going children in India—their moral and religious environment—curricular problems and the difficulties in connection with them—condition of 'appreciation' teaching in secondary schools of the Bombay Presidency—dissatisfaction of children in relation to the work and activities in schools—how aesthetics may serve as a reliever—value of creative arts in schools—difficulties in obtaining the correct place for aesthetics in Indian schools.

10. Dr. Indra Sen, Delhi.

XVI. VOCATIONAL GUIDANCE.

(Section of Psychology and Educational Science.)

Dr. J. M. Kumarappa, Bombay, presided.

1. Mr. M. N. Banerji, Calcutta.

(1) Importance of Vocational Guidance—Vocational Guidance abroad and in India—special work by applied section of Psychology, Calcutta University.

(2) Distinction between vocational selection and vocational guidance —Vocational selections—Selection of best employees—Analysis of qualifications required for the particular job—Formulation of tests—Need of co-operation of Factories, Mills, Business houses, etc., for giving Psychologists opportunities of preparing selection tests.

(3) Vocational guidance—Guidance of individuals to their best fitted vocations—special abilities required by the most important vocations —Development of tests for these abilities—Inventory of individual's capacities—his special abilities—his general intelligence—his temperament, emotivity, etc., as well of his financial capacity, social position, etc.

(4) General intelligence and vocations—intelligence requirements of various occupations—suitable tests—our experience.

(5) Performance tests and vocations—Different tests—Discordant results—Our views.

(6) Importance of emotional life and temperament in achievements—Temperament and personality tests—Our findings so far obtained.

(7) Age of Vocational Guidance—Importance of infancy on personality—Age for first guidance—Age for further advice.

(8) Appeal to School authorities, Universities, Government, Factories, Business houses, etc., to co-operate with Psychologists to give Vocational Guidance to our boys and girls.

2. Prof. N. N. Sengupta, Lucknow.

Methods of Vocational Guidance.

(1) Vocational Selections and Vocational Guidance. Distinction between the two processes.

(2) Limitations of Psychologists in offering Vocational Guidance. Psychological data constitute only one type of data. Other factors such as (*a*) personal choice, (*b*) social and economic circumstances, and (*c*) temperamental trait, are also to be considered.

(3) Methods of guidance—Methods of Vocational Guidance depend upon four general conditions, viz.: (*a*) the character of the vocations, (*b*) technique available for the purpose, (*c*) the institutions that are set up for the purpose, (*d*) the nature of training that the Vocational Guidance counsellor receives for carrying on his work.

(4) Conclusions: Process of Guidance is exceedingly complex. It must take into account many types of data of varying degrees of reliability. It also depends on the conditions of Industry, Legislations and Finance of country.

3. Dr. Indra Sen, Delhi.

The Importance of Environmental Factors in Vocational Guidance.

(1) Vocational Guidance, as a branch of Applied Psychology, aims at giving advice to an individual on the basis of 'a systematic examination

of his mental and bodily conditions as to the occupation he fitted and unfitted'.

(2) But the importance of the environmental factors can hardly be ignored. The environment determines the world of work, which is the logical antecedent of all Vocational Guidance. The occupational opportunities of a society are determined by its state of civilization, highly industrial or otherwise, and the cultural and politico-economic conditions of the country; these circumstances of a society's life will make a difference to the nature and kinds of occupations open, the number of vacancies available. A realistic exploration of the occupational avenues offered by a country is, therefore, a fact precedent to the work of Vocational Guidance.

This is an environmental factor of extreme practical importance.

After a preliminary ascertainment of the avenues of employment has been completed, can the scientific work of 'occupational description' on 'job analysis' be undertaken. Incidentally, occupational description, which constitutes half the work of Vocational Guidance is entirely an environmental investigation.

(3) Theoretically, environment is the necessary correlate of personality, through continuous intercourse with which the human individual grows. And, therefore, the environment, physical and social, which has been the state of his life-history, is capable of providing valuable practical clues to the understanding of personality. Home environment, as we know from Psycho-analysis, may engender conflicts in early childhood, give rise to anti-social tendencies and thus render an individual unsuited to vocations requiring abundant social dealings.

(4) Vocational Guidance, strictly speaking, does not consist in advising an individual to do this or that in life. He is, in fact, helped by the Vocational Counsellor through the instruments of tests and analyses of occupations to discover his own aptitudes and interests, appreciate the requirements of the various likely occupations, and then, by comparing the two, choose for himself the vocation, which he seems to like most. The final deciding factor is the consultant's own 'liking', no doubt as modified, more or less, by the enlightening guidance of the psychologist and his tests. But we must naturally inquire as to the character of this 'liking' or 'interest'. And if we analyse it, even where a sufficiently objective attitude had been taken up, we may still find social suggestion working in it. It is so very difficult to make sure that interests are genuine and not reflections of friends' and parents' likes.

That too would involve the play of an environmental factor.

(5) However, the above emphasis on environmental factors should not be interpreted to disparage the basic assumption of Vocational Guidance, as embodied in Bingham's theory of aptitudes 'that a person's potentialities are fairly stable' and 'that the changes which undoubtedly do occur in the relative potency of these factors are seldom sudden and that they occur within limits, which can often be ascertained in advance.'

4. Mr. J. M. Sen, Krishnagar.

Place of Intelligence Testing in Vocational Guidance.

(1) Vocational Guidance and measurement of human capacities—Difficulties of measurement—Essentials of valid scales of measurements—Place of Terman-Merril Tests and of Performance Tests in Vocational Guidance.

(2) Importance of temperament and character in vocations—Need of study of personality for Vocational Guidance.

5. Dr. Nirode Mukherjee, Calcutta.

Place of Intelligence Testing in Vocational Guidance.

Present status of 'Intelligence' is not as secure as it was a quarter of a century ago. However, it is necessary, for practical purposes, that a definition for Intelligence should be established. From the above point of view Spearman's definition in terms of a Universal Factor seems to be the most plausible one. If Intelligence Testing implies quantitative comparison of 'General Intelligence' then mere verbal tests are quite unsatisfactory, they are more misleading than helpful.

Concern for minute gradations of Intelligence for purpose of Vocational Guidance is sheer pedantry, units may be expanded to save time and boredom. When all the precautions have been taken it may be reminded, that there is a danger of using the results of Intelligence Tests for Vocational Guidance, like the readings of manometer or ampimeter.

As far as India is concerned it would be a vain endeavour to standardize any battery on all-India basis, tests must be devised to suit each lingual province separately. Even then it should be explicitly stated the type of people for whom the particular set is standardized.

6. Mr. S. Jalota, Bombay.

Age of Vocational Guidance.

(1) Age when Vocational Guidance would prove most helpful to the individual has not been properly investigated.

(2) Interest and ability of a child for a certain vocation change within limits from age to age. Socio-economic conditions and other environmental factors alter materially interests and ambitions as the child passes from childhood to adolescence.

(3) Rôle of Oedipus Complex in the choice of parents' vocation—Hence arises the difficulty in proper assessment.

(4) Necessity of applying Vocational tests once at the age of 6 to 8, further at the age of 16 to 18, final advice at the age of 25 to 30.

7. Mr. Sarojendranath Roy, Calcutta.

Performance tests in Vocational Guidance.

Performance tests may broadly be described as practical problems for the solution of which the testee has to manipulate some concrete materials or to perform some specific task. These tests were first developed in connection with the training of mental defectives. Later they came to be utilized for the purpose of training normal children also, as for example in the Montessori method of teaching. They are now also recognized as indispensable requisites in Vocational test programmes, both in Vocational Guidance as also in Vocational Selection. Some important points of theoretical and practical consideration regarding the meaning of the term performance tests, their need in Vocational Guidance, proper way of interpreting the test scores and so on. Description of some of the performance tests adopted and extensively applied in the Department of Psychology, University of Calcutta. Discussion of the results so far obtained.

8. Mr. D. Ganguly, Calcutta.

Temperamental Factors in Vocational Guidance.

Every vocation has its own special type of demand on the person who comes into its form and likewise every man has his individual talent and temperament and accordingly he is capable of discharging the responsibility for a particular type of vocation only. Selection of vocation does not only depend on the level of intelligence and special abilities of an individual but on his temperament as well. Assessment of temperament of an individual, when he is to be advised as to his suitable future career, is thus of great importance.

Unfortunately, there remains an ambiguity in the concept of temperament as also in the concepts of character and personality. Sometimes they are interpreted as different cognizable factors and at other times they are supposed to overlap one another to a great extent losing individual distinctiveness.

The dictionary definitions of the concepts of temperament, character and personality are given. The definitions accepted in the field of the science as far as could be gathered are also given. It is shown that the ambiguity in defining these concepts still persists. The causes underlying this ambiguity have been discussed and new definitions of temperament, character and personality have been attempted. These are expected to remove the existing confusion in the use of these terms. Some of the tests that are now prevalent and go by the name of temperamental tests, according to the definition suggested in this paper, cannot be accepted as tests of temperament. New tests of temperament and personality are yet to be framed to conform with a new definition adduced. The criteria of framing such tests have been discussed.

A historical survey of the previous works on temperament and its allied factors is presented here also.

9. MR. T. K. N. MENON, Baroda.

Some of the recent researches in Vocational Guidance and conclusions —The limited value of Vocational tests—Difficulties of psychological analysis of the results—The need for separate authorities for Vocational Guidance and placement.

10. DR. RABINDRANATH GHOSH, Calcutta.

The difference between Vocational Selection and Vocational Guidance lies in the difference of approach. Vocational Selection is primarily to the interests of the employer. Vocational Guidance looks to the happy adaptation of the individual to a particular vocation to which he would be best suited. Vocational Selection therefore pays little attention to the happiness of the individual who is to be employed. It is chiefly concerned in finding out the individual who will be most efficient for the job. Whether that person would be better suited to another job is not the task of the Vocational Selector to find out. Having the knowledge of the requirements of the job his task is to find out ways and means by which the employer or the employer's representative will be able to determine which of the job-seekers will satisfy the requirements most. He is naturally interested in the assessment of Talent factors and sometimes the Temperamental Contra-indications. From experience acquired in the lock-outs and strikes, the Vocational Selector has taken up the task of finding out Temperamental Contra-indications. A dissatisfied worker has been observed responsible for producing such conditions that ultimately lead to some kind of disturbance in the organization of the work. A very ambitious worker is contra-indicated for jobs where there is little possibility of satisfying his ambitions. In this matter of safeguarding the interests of the organization Vocational Selection is at an advantage. Vocational Selector can know the psychological conditions and conditions otherwise prevailing at the spot where the work is executed. Psychologically the most important factors he will have to consider are those arising in such human relationships as the employer-employee relationship, the employee-employee relationship. In the respects of these considerations the

Vocational Selection differs from Vocational Guidance in its character of approach and methodology. Vocational Selection will have to reduce L.T.O. and to detect misfits and drifters in order to increase the amount of output. It is very specific in measuring special abilities and aptitude, whereas Vocational Guidance has to be content with general aspects of mental and special ability tests.

11. DR. S. DATTA, Rajshahi.

An analysis of the Educational needs of Bengal based on figures of employments.

The method of tackling the Educational needs of a country is various. Accepting the theory that the energy of a nation is best conserved if there be a planned education of the people suited to his future avocation, an analysis has been made of the number of persons employed in different pursuits of life from the available census data. These have then been suitably grouped according to their educational needs and an estimate arrived at of the number of different types of schools which would be necessary for a planned development of education in Bengal in relation to its figures of employments.

12. MR. PARS RAM, Lahore.

Avenues of employment—A necessary item in the Vocational Guidance Programme.

New avenues of career are determined by (1) International situation, such as war, exchange ratio, tariff barrier in other countries and reorganization of industries in other countries; (2) differentiate development in the existing professions; (3) changes in the consumer's tastes; (4) changes in the machinery; (5) availability of power, such as electricity; (6) availability of raw materials.

A Vocational Guidance agency has to make a careful note of the avenues of employment thrown open by the above factors and the abilities required by the new trades and advantages and disadvantages of each trade as well as the opportunities for apprenticeship. This information must be properly broadcast so that a favourable atmosphere for new vocations may be created.

The following difficulties prohibit people from taking to new vocations.

(1) Lack of availability of suitable implements and instruments in India. Every small implement has to be brought from elsewhere.

(2) Shy Capital: Those who know crafts have no capital and those who have capital are extremely cautious of investing in new vocations.

(3) Lack of availability of cheap power, such as electricity, etc.

(4) Social factor—caste prejudices to education.

These difficulties can be overcome by (1) propaganda, (2) Government coming forward to help young people, (3) a research in the manufacture of tools for various trades, (4) a reorganization of education along the lines of the Wardha Scheme of Basic Education.

13. DR. J. M. KUMARAPPA, Bombay.

Occupational information—An aspect of Vocational Guidance.

The future of the individual concerned and the good of the society to which he belongs hang upon the proper choice of a life career. Accordingly much attention is now being paid in the western countries to what is called 'Vocational Guidance'. It is a matter of regret that India has not taken up the question seriously yet, though the need for Vocational Guidance is greater in our country. The prevalent system of education here is to be blamed for the little direct regard to the needs of industry and commerce. Our young men often attempt to enter the overcrowded learned professions and make a poor show in life. Vocational Guidance tend to save the wastage of human energy and help the entrants to choose occupations for which they are best fitted by natural ability. In a complete scheme of Vocational Guidance are included the steps of supplying of occupational information and helping to get the necessary preparation for a particular occupation. For a successful choice of career discovery of natural abilities is of as much importance as knowledge of the needs of the world of occupations. Machinery for surveying occupational needs and opportunities should be set up in every province. Enterprising teachers may help the cause by undertaking such surveys in their own locality on a small scale. For facility of observations the large occupational groups may be classified under eight different heads: Agriculture, Forestry and Fishing, mineral extraction, manufacturing and mechanical industries, transportation and communication, commerce, public services, professional services, and domestic and personal services. These larger groups may be further subdivided into smaller groups. For the purpose of investigation of an occupational field data should be gathered under the heads: Importance of the occupation, division of work, qualifications required, starting on a job, opportunities for advancement, and approved institutes where training may be had. Having collected the necessary data regarding different vocations these should be presented to the pupils. In the lower grades information may be presented in story form, more accurate information being reserved for the higher grades. The first step in Vocational Guidance must be undertaken by the school.

14. Mr. Jagdish Singh, Preet Nagar, Punjab.

15. Dr. (Miss) K. H. Cama, Bombay.

16. Mr. U. S. Gheba, New Delhi.

XVII. FACTOR ANALYSIS.

(Sections of Psychology and Educational Science, and Mathematics and Statistics.)

Prof. K. B. Madhava, Mysore, presided.

1. Dr. Gopeswar Pal, Calcutta.

(1) Hierarchical order of correlations—Explanation of Hierarchy in terms of two factors—Formulation of 'two-factor theory' by Spearman—Its criticism by Thorndike—Other possible explanation of Hierarchy in terms of group factors by Thomson—Tryon's criticism of 'tetrad criterion' on factual grounds—Establishment of inadequacy of 'two-factor' theory.

(2) First work of multiple factor analysis by Kelley—Thurstone's works—His methods of extracting independent factors—Hotelling's method of principal components—Relative advantages and limitations of these methods.

(3) Difficulty of majority of psychologists in following mathematical reasoning and techniques involved in these methods—Clear understanding

of the use and limitation of factor analysis require sound mathematical aptitude.

(4) Primary object of factor analysis—Are the factors isolated by analytic methods simply and solely mathematical entities or can they be conceived of as representing psychological unities ?—Speculative nature of determining psychologically the identity of the factors isolated—Difficulty of explaining negative factor loadings—usefulness of factor analysis.

2. Mr. B. B. Kuppuswamy, Mysore.

Factor analysis and its usefulness.

I. The primary object of Factor Analysis.

The search for fundamental variables or dimensions of abilities—Faculties and factors.

II. Factors and abilities.

Discovery of hierarchical order and the hypothesis of common factor—measurement of communality and specificity of a test score—same set of correlations can be factorized in innumerable ways—the factor will have significance only if it is identified with some psychological ability.

III. 'Independence' of factors.

Orthogonal factors—Implications of correlation and non-correlation.

IV. Negative saturations.

Generally, correlation coefficients are positive—The negative correlations are looked upon as due to errors of sampling—Burt's contention—Is measurement of 'disability' positive or negative ?—Do phenomena of inhibition and bipolarity necessitate negative loadings ?

V. Limitations of factor analysis.

Methods of factor analysis—tools to test psychological hypotheses—the Status of 'G'—Factors have a conceptional status and not entities.

VI. Vocational Guidance and two-factor theory.

The contention of Thomson and Hull—The meaning of specificity—Group factors and occupational analysis and aptitude testing.

3. Prof. S. Jalota, Sholapur.

Psychologist's object in factor analysis.

(1) The need for exactness—the dignity of mathematically expressed data—statistical treatment is primarily a relation between numbers—Its adequacy depends upon the peculiar relations existing between the numerical facts and their objective data. Mental experience has only a limited field for accurate computation, e.g. Fechner's Psycho-physics.

(2) The large number of psychological measurements required mathematical abbreviation—Mathematical formulae had a descriptive rôle —Peculiarities of relationships between numerical data have been interpreted as representative of actual psychological relationships—This transformation of mathematical relational facts into characteristics of mental organization has given rise to the theory of 'factors' and the field for psychological 'factorial' analysis.

(3) Two problems: (i) Is mathematical analysis also an analysis of mental facts? (ii) Are mathematical results alone a sufficient evidence of psychological data?

(4) Psychological analysis should be primary. If mathematical analysis is corroborative, it is of use to psychology. But if main stress is laid upon numerical analysis, and then an attempt is made to interpret the numerical results in terms of psychological factors, the consequences are highly deceptive and likely to be fallacious.

4. DR. NIRODE MUKERJI, Calcutta.

Philosophical and Practical aspects of factor analysis.

Objects of factor analysis are to describe and predict, quantitatively, mental 'terms' or patterns on which our activities are based. Factorial concepts adopted are empirical principles of classification of the mental 'terms'.

'The mathematical part of the factorial argument is for the most part deductive, and therefore, like all deductive reasoning is admittedly unable to guarantee the reality of the results deduced . . . . . Induction is necessary at the beginning to suggest the initial postulates and again at the end to see whether the empirical facts answer to the corollaries deduced.' (Burt). Induction on the basis of determining a reality is as much needed in factor analysis as in any other quantitative science.

Mathematically, there are significant differences in the various methods of factor analysis, psychologically, the existing schools may be divided into two camps. Thurstone, Kelley and Hotelling prefer to determine the factor loading first and then try to determine if there be any psychological foundation of the factors. Whereas, in the procedure adopted by Spearman '*g*' is isolated with less hesitation; psychological determination of '*s*'s follow not a very different procedure from the previous one, education being a common factor in both of them.

Factor-concept. Natural inertia in an ordinary person resists an altogether novel conception in any branch of science; consequently, attempts are occasionally made to link factor-concept with long dead faculty-conception. (Factors denote activity-patterns, the *co-ordinates* being accepted-arbitrary-terms. This sort of conception though seems to be queer in the domain of psychology are frequently used in everyday life under such terms as 'north-easterly direction'.) From the above point of view the negative loadings can be interpreted psychologically.

5. PROF. K. B. MADHAVA, Mysore.

Factor analysis is the natural consummation of the testing movement by which experimental psychologists have attempted to sort mankind, especially children, into different categories of ability, and incidentally to ascertain the components, if any, of the general term, ability. Such a search looked plausible, indeed necessary, because of Professor Spearman's discovery in 1904 that the coefficients of correlation between suitably devised tests tended to fall into heirarchial order which could be explained, mathematically, as due to the operation of a common factor, and this was the start of the famous two-factor theory, and in turn the precursor of the multiple factor analysis. There is a natural feeling that factors or components, may be more enduring entities than the innumerable and changing tests used to find them, but such factors should only be admitted as statistical coefficients as real or as unreal as an average or an index of cost of living. Though under defined conditions and assumptions they are most useful as descriptive terms it should be emphasized that like all other statistical coefficients they change with the sample and with the conditions and assumptions under which they are computed.

The speaker would confine himself to the actual computation of the factors of a given, battery of tests because then alone would the true implications of the various steps come out in their full significance. Accordingly, the results of a battery of 8 tests conducted in 50 individuals were illustrated by projecting on the screen one by one the several steps in the arithmetical process. In the limited time at the disposal of the meeting only the more popular method of Professor Thurstone could be dealt with at length, which method moreover can be reached by a generalization of Spearman's idea of zero tetrad differences. It was however added that when the geometrical picture was actually reviewed and handled the method of Hotelling's principal components could be conceived as a more general solution of a complex of statistical variables. His principal components are those axes, all at right angles to one another (and therefore securing independence of tests) which lie along each principal axis of ellipsoids of equal density of the population of persons tested. If we know all the factor scores of an individual we know precisely where he can be found in the assembly, but if the factors can be chosen so that a few of them give a good approximation to the information given by a large number of tests, there is obvious economy in their use.

The illustration was then completed by projecting twelve sheets showing the results of the calculations by the Thurstone centroid method of analysis in the selected example. At the appropriate places were explained the meaning and significance of negative loadings, reversing the axes, extending the axes and rotating the axes. Also a model of the 'simple structure' in three dimensions with a tin pattern of the best fitting spherical triangle was exhibited. Some account was also given of reciprocity of loadings and factors, and the special features of a double centred matrix which yield what are known as profile correlations brought to light by Burt's researches were pointed out. On the mathematical side, factor analysis, it was pointed out, had made much use of matrix algebra, and even if from the abstract point of view there would remain some psychological subtlety which would elude mathematical precision, the contribution of the mathematical method to ascertain and isolate the influence of multivariate selection would always remain a triumph in inductive logic.

6. Mr. R. C. Bose, Calcutta.

He spoke on Hotelling's method of *Principal Components*. He explained the meaning of these Principal Components and gave the mathematical theory on which their use is based. Whether these components have any psychological counterpart must be left to the psychologists to determine. The statistician is content with analyzing the data (in this case the scores resulting from the tests) before him, so that he can give a condensed picture of it.

XVIII. THE RACIAL CLASSIFICATION OF INDIA.

(Section of Anthropology.)

Prof. M. H. Krishna, Mysore, presided.

Prof Krishna opened the discussion by tracing the history of racial studies in India and laid particular stress on the results achieved by Risley as also on their defects. He also dealt with the criticisms of later writers like Chanda, Ghurye, Thurston, Richards, Hutton, Eickstedt, Guha, etc., and pointed out that there was a great deal of agreement amongst the recent writers on the subject. He drew a map of the races of India according to recent researches, and suggested a provisional nomenclature as given in his Presidential Address. He proposed that a thorough survey of all parts of India may be made after the war.

2. Dr. G. S. Ghurye, Bombay.

Dr. Ghurye pointed out that the racial classification of India may have social as well as political significance in lines similar to Hitler's racial ideas. The affinities outside India are also important. Nomenclature like Indo-Australoid may have national importance. The discussion therefore is not merely academic. He said that Risley's first critic was Cooke who pointed out the racial continuity between the Punjab and U.P. He also said that there is no real brachycephal in India but only mesocephal, and also many smaller types among the Indian dolichocephals. Eickstedt is inclined to agree with his views, Dr. Guha has not distinguished between different sections of castes. After examining Dr. Hutton's views, he mentioned as to how a proper classification of affinities and nomenclature should be made. But he said that there should not be a proper classification until a survey had been made.

3. Sir T. Vijayaraghavacharya, Udaipur.

Sir T. Vijayaraghavacharya said that migrations came in waves and each formed a stratum. The South Indians are perhaps an earlier stratum of the same race as the North Indian.

4. Dr. J. F. Bulsara, Bombay.

Dr. Bulsara pointed out that it will be better to keep to the chief standard groups, and to keep apart culture for the present.

The President in winding up the debate stated that it was better to have a provincial analysis and map instead of the present negative position. But it was quite necessary to have a thorough survey after the war.

XIX. THE ANTHROPOLOGICAL APPROACH TO INDIAN SOCIOLOGY.

(*Section of Anthropology.*)

Prof. M. H. Krishna, Mysore, presided.

1. Dr. J. F. Bulsara, Bombay.

Dr. Bulsara traced the history of the relation between Anthropology and Sociology and remarked that it was rather difficult to distinguish between the two, since they overlap. But the study of Anthropology has come to the aid of administrators in Africa and elsewhere. It will therefore be helpful to some extent in our city administration also.

2. Dr. G. S. Ghurye, Bombay.

(1) Compte, Spencer and Hobhouse contemplated or actually made use of Anthropological material and the latter two pursued the approach of Anthropology for the elucidation of certain Sociological problems.

(2) A large number of the principles of Sociology about which there is a consensus of opinion among American Anthropologists are concerned with the cultural processes. Culture is best studied by the Anthropological method.

(3) Ethics and Psychology have adopted the Anthropological approach in their studies with great advantage.

(4) National character and its relation to races are very important in Politics. National characters and races are also important in Sociology. The topic is of special importance in Indian Sociology. Race is studied by Anthropologists.

(5) Analysis of present Indian Culture and its past history are very important for Indian Sociology. Anthropological approach is the best for such study.

(6) Aspects of social differentiation in India are illuminated by the study of Anthropological material and best understood through it.

(7) Problem of the so-called criminal tribes is understood largely through Anthropological approach.

(8) Progess and welfare of the inhabitants of the 'excluded areas' can best be achieved if the problem is tried to be tackled through the Anthropological approach.

Anthropological approach thus is the most important approach for the study and solution of some of the urgent problems in Indian Sociology.

The President in his concluding remarks drew attention to the anthropological foundation of the rural life in India, of castes, etc., and concluded by saying that a study of Anthropology in India was absolutely necessary to understand Indian Sociology, although it might be difficult sometimes to distinguish between the two.

XX. THE SEQUENCE OF PREHISTORIC CULTURES IN INDIA.

(Sections of Geology and Anthropology.)

Mr. D. N. Wadia, Colombo, presided and opened the discussion.

Opening Remarks.

It is deplorable that no clear data for a stratigraphic study of the prehistoric cultures are available from any centre in India. The linking up of the older human relics with a definite geological datum-plane such as the Upper Siwaliks of North India yet remains to be achieved. De Terra's find of the Soan artefacts from the 'top-beds of the boulder-conglomerate' stage is of great interest, but his classification of the boulder-conglomerate beds in terms of the Upper Siwaliks sequence is open to question. De Terra has taken the huge superficial gravel deposits over-spreading Rawalpindi and Attock districts and covering tracts in Jammu as belonging to the boulder-conglomerate horizon, whereas there is no doubt that a variable but distinct hiatus occurs between the much-disturbed and often vertically disposed boulder-conglomerate strata and the generally little-disturbed overlying boulder and gravel beds of North-West Punjab, which are at many places implementiferous. He again ascribes a middle Pliestocene geological horizon to the boulder-conglomerate while the Indian geologists have consistently argued a lower Pleistocene age for these beds, both from the fossil as well as stratigraphic evidence. So far, therefore, the question of dating the earlier traces of man's existence in India in terms of the Siwalik sequence remains undecided.

The discovery of numerous palaeolithic implements in the Sabarmati valley near Ahmedabad from an alluvial terrace, at a depth of 50 feet from the surface, by a research party sponsored by the Archaeological Survey of India and the Gujarat Research Society is of more than ordinary interest. This find may lead to other important discoveries in human palaeontology in the terraces and older alluvium of Gujarat valleys in future. The members of the party deserve congratulations on their successful exploration.

2. P. E. P. DERANIYAGALA, Colombo.

Ceylon possesses two prehistoric culture phases which differ widely from each other both in the animal remains occurring in association with each as well as in the types of their artefacts. Both phases are named from their type localities and are based upon excavated material in the Colombo Museum (Deraniyagala, Sept. 23rd, 1940).

(*a*) The lower or older of the two is the *Ratnapura* culture phase and occurs down to a depth of 40 feet below the surface. Its artefacts are generally crude, with no retouching, and are more akin to the earlier Sohan types than the quartzite ones of the neighbouring Madras Presidency. Not infrequently they occur in a thin but most interesting fossiliferous horizon 6 inches to 3 feet thick which combines remains of such comparatively recent animals as deer, bovines, and an extinct race of *Elephas maximus* Linne, with such archaic forms as hippopotamus, and members of the Anthracotheriidae. It is possible that the last two forms persisted in Ceylon after their extinction on the mainland, and that the Island's stone artefacts are not older than the Boulder Conglomerate of the Siwaliks, but it is also possible that they go as far back as the Pinjor which contains *Merycopotamus* the last of the Anthracotheriidae.

(*b*) The upper or younger culture of Ceylon is the *Balangoda* phase and occurs down to a depth of 6 feet below the surface. Quartz and Chert pygmies, and other types familiar from the neolithic of Ceylon characterize it, but larger ground or polished artefacts were unknown until recently. Excavation in caves has now yielded a number of pitted anvils and also celts 70 to 127 mm. long from the upper level of the Balangoda phase. As these celts are generally fashioned by grinding down pebbles, of rocks less resistant to weathering than quartz, such artefacts only survive under exceptional circumstances, and have hitherto remained undiscovered. No celt is perforated, but each possesses diametrically opposed, shallow, conical pits near its short axis, and displays scars of impact at one or both ends. The pits are doubtless of value in securing a firm grip or in hafting; the term *Balangoda celt* is proposed for these pitted weapons. In association were also found bone artefacts usually trapezium shaped and conically pointed at the two ends. Haematite and graphite were used as pigments and several grinding stones, mortars and celts were found smeared with the former mineral. Somewhat similarly pitted pebbles are figured by Evans (1897) from lake deposits in the British Isles and also mentioned from parts of America while Dalton (1926) mentions some from Bellary near Madras. The animals employed as food by *Balangoda* man are all of existing species and the abundance of aquatic molluscs and crabs suggests that the upper or last phase was a lake culture. The prevalence of bones of the jungle fowl *Gallus lafayetti* Less., a bird taboo to the Väddhas of Ceylon who also possess no tradition of having utilized stone weapons, suggests that there is little in common between the cultures of Balangoda man and this race. As Ceylon retains some important aspects of stone culture which have been submerged by other phases upon the subcontinent of India, their study is a *sine qua non* for correlating these phases and bridging the gaps between them.

3. RAO BAHADUR K. N. DIKSHIT, New Delhi.

He described the present unsatisfactory position of our knowledge of the subject. He drew attention to the chief problems for investigation like the hiatus in palaeolithic cultures in India particularly in the later palaeolithic, the possibility of the microlithic cultures of the Sabarmati Valley belonging to the mesolithic times, and the precautions to be taken by the explorers. He laid special emphasis upon the importance of the Brahmagiri site where a stratigraphical study of some stage of prehistory has been possible.

4. MR. V. D. KRISHNASWAMI, Madras.

He showed a slide giving a detailed tabular account of the geological and prehistoric stratification to be expected in the course of excavations.

5. PROF. D. SEN, Calcutta.

The Lower Palaeolithic is well represented in India by pebble-and-core cultures and flake cultures in some well-known and dated sites in the south, central and north India. The relative chronology, however, of the two cultures is not yet fully established. The Upper Palaeolithic is not so well known though a variety of blade industries typologically reminiscent of the Aurignacian and Magdalenian have been found from some sites, especially from the Narbada valley, coastal Bombay, the Soan valley and Rorhri-Sukkur (proto-neolithic ?), but their dates are not yet fully established. The continuity from the Lower to the Upper Palaeolithic has also not yet been established though some good attempts have been made in the Soan valley and in the Bombay coastal sites. The latter may range from mid-palaeolithic to full microlithic and a blade-and-burin industry evolves from a clactonian flake-culture. If such likely sites are further explored and excavated, particularly the regions in the Narbada, Soan and Bombay coasts and older sites reopened, the results may throw some useful light on the problem of continuity in the palaeolithic history of India. The gap between the Palaeolithic and Neolithic civilizations remains unbridged and unexplained though lithic remains of both the civilizations occur in large scales, particularly in the peninsular India. An interesting section has been found in the Sabarmati valley in Gujarat which if properly explored and excavated may yield valuable results. The innumerable neolithic sites in India offer interesting typology. If at least a study based on the distribution of neolithic celts is attempted, it may establish a chronology. Mesolithic industries occur in some places but their typology or chronology is far from being established. The Chalcolithic probably succeeds the Neolithic in the North while the Iron Age succeeds the Neolithic in the South though their succession is not clear. So far there is no evidence of the Iron Age in North India as there is no evidence of the Chalcolithic in the South. It is not unlikely that the succession of prehistoric stages is different in the North and in the South. If a study of prehistoric archaeology and geography is attempted on a regional basis, and the results correlated, the stages in Indian Prehistory may be brought together in the light of their succession and geographical background.

6. DR. A. S. KALAPESI, Bombay.

He described the discovery of prehistoric artefacts at Borivli near Bombay.

7. C. MAHADEVAN, Hyderabad-Deccan.

Parts of Hyderabad State are rich in the relics of prehistoric culture such as cave dwellings, stone bruised graffitti, paleolithic and neolithic artefacts, stone circled graves of different types, dolmens, stone alignments, ash mounds and rock paintings. Proto-historic sites containing painted pottery, conch shells and glass bangles, precious and semi-precious beads and mud seals have been noted in several places. A classification of all these in point of sequence was attempted in the paper.

It was pointed out that whereas attempting a sequence of cultures was perfectly understandable, it would be dangerous to classify them in terms of any specific date as different cultures (from the most primitive to the highly civilized) co-exists contemporaneously in the same country.

Some other gentlemen also took part in the discussion, and the President of the Section wound up the debate.

At the end of the discussion the following resolution was passed by the Section unanimously:

'That the study of Anthropology by means of research and teaching be encouraged by the Government of India and the Governments of Provinces and States, Universities of India and the cultured public by providing lecturerships, scholarships and fellowships.'

LIST OF MEMBERS, TWENTY-NINTH INDIAN SCIENCE CONGRESS.

HONORARY MEMBERS.

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Buller, A. H. R., Lately Professor of Botany, University of Manitoba, U.S.A.
Eddington, Sir A. S., Kt., M.A., D.Sc., LL.D., F.R.S., Plumian Professor of Astronomy and Experimental Philosophy, University of Cambridge, Cambridge, England.
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Jung, C. G., Professor of Psychology, University of Zurich, Switzerland.
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Simonsen, John Lionel, D.Sc., F.I.C., F.R.S., Professor of Chemistry, University College of North Wales, Bangar.
Visvesvaraya, Sir M., K.C.I.E., Uplands, High Ground, Bangalore.

ORDINARY MEMBERS, 1941-1942

As at the close of July 15th, 1941: Rule 4.

The names of Life Members are marked with an asterisk.

A

Acharya, C. N., M.Sc., Ph.D., F.I.C., Department of Biochemistry, Indian Institute of Science, Bangalore.
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Agarwal, (Miss) Shanti, M.A., Lecturer in Philosophy, Babu-Ganj, Lucknow.
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Ahmad, Nazir, O.B.E., J.P., Ph.D., F.Inst.P., F.N.I., Director, Cotton Technological Laboratory, Matunga, Bombay.

Ahmad, Taskhir, Assistant Entomologist, Imperial Agricultural Research Institute, New Delhi.

Ahmed. Nafis, M.A., B.E.S., Professor of Geography, Islamia College, Calcutta.

Aiyappan, A., M.A., Ph.D. (Lond.), F.R.A.I., Offg. Superintendent, Government Museum, Egmore, Madras.

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Aiyar, R. Gopala, M.A., M.Sc., Professor of Zoology and Honorary Director, Madras University Zoological Laboratory, Triplicane P.O., Madras.

Aiyar, T. V. Ramachandra, B.A., F.R.Met.S., Chief Observer, Government Central Observatory, Bangalore.

Aiyer, A. K. Yegna Narayan, M.A., Dip-in-Agri. (Cantab.), N.D.D., F.C.S., Retired Director of Agriculture; Sankarapuram, Bangalore.

Ajrekar, S. L., F.N.I., I.E.S. (Retd.), 855, Shivajinagar, Bhandarkar Institute Road, P.O. Deccan Gymkhana, Poona 4.

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INDEX.

[A Roman numeral has been prefixed to the Arabic page number. These Roman numerals indicate the parts which each have their independent page numbering in Arabic numerals.]

B

C

D

E

F

H

I

J

K

L

M

N

O

P

Q

R

S

U

W

X

Y

Z

IMPORTANT NOTICE

This programme is only provisional. A revised and detailed programme including the list of local excursions, social functions and entertainments will be issued to members on Thursday, January 1st, 1942, from the Local Secretaries' Office.

The abstracts of papers, as far as available, to be read at the Discussions will be issued at the same time.

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18. Sir C. V. Raman, Kt., Nobel Laureate.
29. Dr. B. Prashad, D.Sc., F.L.S., F.Z.S., F.R.S.E., F.R.A.S.B F.N.I.
30. Rai Bahadur Dr. S. L. Hora, D.Sc., F.L.S., F.Z.S., F.R.S.E., F.R.A.S.B., F.N.I.

31—44. (f) *Sectional Presidents.*

(g) *Elected by the General Committee.*

45. Prof. Y. Bharadwaja, M.Sc., Ph.D., F.L.S., F.N.I.
46. Prof. F. R. Bharucha, B.A., D.Sc., F.N.I.
47. Prof. H. K. Mookerjee, M.Sc., D.I.C., D.Sc.
48. Prof. B. Narayana, M.Sc., M.B., Ph.D., F.R.S.E.
49. Prof. B. Sanjiva Rao, M.A., Ph.D.
50. A. C. Ukil, Esq., M.B., M.S.P.E., F.S.M.F.B., F.N.I.
51. Prof. K. Venkataraman, M.A., M.Sc.Tech., Ph.D., D.Sc., F.I.C.

Sectional Committees
1941-1942

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Mr. J. L. Bhaduri	..	

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Prof. B. Narayana	..	
Dr. B. B. Dikshit	.	
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13. Psychology and Educational Science—

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Mr. K. C. Mukherji	..	
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Mr. D. Ganguly	..	
Dr. I. Latif	..	
Dr. Gopeswar Pal	..	

14. Engineering—

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Prof. S. K. Roy	..	*Sectional Correspondent.*
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Dr. Anant H. Pandya	..	*Past Recorder who is an Ordinary Member.*

General Arrangements

The Opening Ceremony of the Congress will be held in the Baroda College Central Hall. All Sections will meet in the College Buildings in the following rooms:—

Mathematics and Statistics	Physics Lecture Theatre, Science Institute (48).
Physics ..	Physics Lecture Theatre, Science Institute (41).
Chemistry ..	Chemistry Lecture Theatre, Science Institute.
Geology ..	Room No. 9 (Arts)
Geography and Geodesy	Room No 21 (Arts).
Botany ..	Biology Lecture Theatre, Science Institute (21).
Zoology ..	Biology Room No. 25, Science Institute.
Entomology ..	Room No. 20 (Arts).
Anthropology ..	Room No. 10 (Arts).
Medical and Veterinary Research ..	Room No. 15 (Arts).
Agriculture ..	Room No. 22 (Arts)
Physiology ..	Biology Lecture Theatre, Science Institute (28).
Psychology and Educational Science. ..	Room No. 1 (Arts).
Engineering .	Room No. 18 (Arts).

The *Office of the Local Secretaries* will be opened in Room No. 17 (Chemistry), Science Institute

The *Office of the General Secretaries* will be opened in Room No. 25 (Biology), Science Institute.

The *Information Bureau* is located in the S. J. Science Institute Library.

The *Reception Room* is located in the Jr. B.Sc. Practical Room (Biology), Science Institute. Stationery and writing materials for the use of the members will be available there. A number of the local daily papers will be provided in this room.

A *Post and Telegraph Office* will be opened in the Chemistry Balance Room (8), East, Science Institute. Members may address their letters C/o Indian Science Congress, Baroda College, Baroda. All communications to the Local Secretaries may also be sent to this address from the 31st December, 1941.

A local branch of the Bank of Baroda is situated in the Chemistry Balance Room (8), West, Science Institute.

A *Telephone Connection* will be available for the use of the members in the S. J. Science Institute Library.

A *Restaurant*, where refreshments will be available, will be opened in the College Compound from the 2nd January, 1942.

Details of the *Excursions* will be announced in the revised programme.

An interesting programme of visits to institutions of educational, scientific, technical and industrial interest is being arranged, details of which will be included in the revised programme.

Badges, a Science Congress Handbook (Baroda, 1942) and a *List of Members* with their local addresses, where known, together with *Invitation Cards to social functions*, will be issued to members from the Local Secretary's Office from the 1st January, 1942 between 9 A.M. and 4 P.M. Members are requested to produce their membership cards when applying for these.

Opening Proceedings and the General Presidential Address:—The Congress will be opened by His Highness the Maharaja Saheb of Baroda in the Baroda College, at 9-30 A.M. on Friday, January 2nd, 1942. The Address of the General President will begin immediately afterwards. Members must be in their seats before 9 A.M.

The Evening Popular Lectures will be delivered in the College Central Hall as follows:—

FRIDAY, JANUARY 2ND, 1942, AT 6-30 P.M.

'Lahul: its people and flora,' by Dr. N. L. Bor, M.A., D.Sc., F.L.S., I.F.S., Forest Botanist, Forest Research Institute, P.O. New Forest, Dehra Dun.

MONDAY, JANUARY 5TH, 1942, AT 6-30 P.M.

'The progress of Industrial Research,' by Sir S. S. Bhatnagar, Kt., O.B.E., D.Sc., F.Inst.P., F.I.C., Director, Board of Scientific and Industrial Research, Government Test House, Alipore, Calcutta.

TUESDAY, JANUARY 6TH, 1942, AT 6-30 P.M.

'The Mica Industry,' by Dr. J. A. Dunn, D.Sc., D.I.C., F.G.S., F.N.I., Superintending Geologist, Geological Survey of India, 27, Chowringhee, Calcutta.

WEDNESDAY, JANUARY 7TH, 1942, AT 6-30 P.M.

'Science and the National Reconstruction in India,' by Dr. Kewal Motwani, A.M., Ph.D., Theosophical Society, Adyar, Madras.

THURSDAY, JANUARY 8TH, 1942, AT 6-30 P.M.

'The Human Brain,' by Mr. Brij Mohan Lal, M.B.B.S., M.SC. (Lond.), Principal, Osmania Medical College, Hyderabad.

DAILY PROGRAMME
(Provisional)

THURSDAY, JANUARY 1ST, 1942.

2 P.M.	Meeting of the Executive Committee.

FRIDAY, JANUARY 2ND, 1942.

9-30 A.M. ..	His Highness Maharaja Sir Pratapsingh Gaekwad, Senakhaskhel, Samsher Bahadur, G.C.I.E., LL.D., Farzande-Khas-E-Daulate-Englishia opens the Indian Science Congress Session.
	General President's Address.
2 P.M. ..	Meetings of the Sectional Committees (in the rooms of the respective Sections).
3-30 P.M. ..	Meeting of the Council.
6-30 P.M. ..	Popular Lecture on 'Lahul: its people and flora,' by Dr. N. L. Bor M.A., D.Sc., F.L.S., I.F.S., Forest Botanist, Forest Research Institute, Dehra Dun.

SATURDAY, JANUARY 3RD, 1942.

9 A.M. to 9-30 A.M. ..	Meetings of the Sectional Committees.
9-30 A.M. to 1 P.M. ..	Meetings of Sections.
12 NOON ..	Presidential Address: Section of Agriculture: 'Some Textile Fibres of India.'
11-30 A.M. to 1 P.M. ..	(1) Discussion on 'Co-education.' (SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE).
	(2) Discussion on 'Necessity of a collection of Insects of India.' (SECTION OF ENTOMOLOGY).
	(3) Discussion on 'Tests of Cement-Surki Mortars under various conditions' and 'Methylated spirits as fuel in Petrol Engines,' (SECTION OF ENGINEERING).
	(4) Discussion on 'Gravity measurements in India' and 'Some gravity problems of Eastern India.' (SECTIONS OF GEOLOGY AND GEOGRAPHY AND GEODESY).
2 P.M. to 4 P.M. .	(1) Discussion on 'Manufacture of scientific instruments in India.' (SECTIONS OF CHEMISTRY, PHYSICS AND MEDICAL AND VETERINARY RESEARCH).

Notes:—Notices regarding *Social Functions* and *Excursions* will be announced by the Local Secretaries at Baroda during the Session.

2 P.M. to 4 P.M. ..	(2) Discussion on 'The use of Factorial and Incomplete Block Designs in Agriculture.' (SECTIONS OF AGRICULTURE AND MATHEMATICS AND STATISTICS).
	(3) Discussion on 'The sequence of prehistoric cultures in India.' (SECTIONS OF GEOLOGY AND ANTHROPOLOGY).
4 P.M. ..	Meeting of the Executive Committee.
	Reception Committee's Dinner.

SUNDAY, JANUARY 4TH, 1942.

Excursions will be announced at Baroda.

MONDAY, JANUARY 5TH, 1942.

9 A.M. to 9-30 A.M ..	Meetings of the Sectional Committees.
9-30 A.M. to 1 P.M ..	Meetings of Sections.
9-30 A.M. ..	Presidential Address: Section of Botany: 'Ecology: Theory and Practice.'
10 30 A.M ..	Presidential Address: Section of Physics: 'Some aspects of X-ray investigations on solids, electrolytic solutions, allotropes and colloids.'
11 30 A.M. ..	Presidential Address: Section of Anthropology: 'Prehistoric Dakhan.'
12 NOON ..	Presidential Address: Section of Physiology: 'The need for the expansion of physiological and pharmacological Research in India.'
11-30 A.M. to 1 P.M. ..	(1) Discussion on 'Origin of salts in the Lakes and soils of India.' (SECTIONS OF GEOGRAPHY AND GEODESY AND GEOLOGY).
	(2) Talk on 'Childhood and Adolescence,' by Mrs Kusum Thakore, M.A. (SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE).
	(3) Discussion on 'Improvement in agricultural implements and machinery.' (SECTIONS OF AGRICULTURE AND ENGINEERING).
	(4) Discussion on 'Essential Oils.' (SECTION OF CHEMISTRY, IN CO-OPERATION WITH THE INDIAN PHARMACEUTICAL CONFERENCE).

2 P.M. to 4 P.M. ..	(1) Discussion on 'The racial classification of India.' (SECTION OF ANTHROPOLOGY).
	(2) Discussion on 'Sex Hormones, their chemistry, physiology, pharmacology and therapy.' (SECTIONS OF CHEMISTRY, PHYSIOLOGY AND MEDICAL AND VETERINARY RESEARCH).
	(3) Discussion on 'Psychological approach to Aesthetics.' (SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE).
2-30 P.M. to 3-30 P.M. ..	Discussion on 'Underground and surface water resources of North India and their utilization.' (SECTIONS OF GEOLOGY, GEOGRAPHY AND GEODESY, ENGINEERING AND AGRICULTURE).
6-30 P.M. .	Popular Lecture on 'The progress of Industrial Research,' by Sir S. S. Bhatnagar, Kt., O.B.E., D.Sc., F.Inst.P., F.I.C., Director, Board of Scientific and Industrial Research.

TUESDAY, JANUARY 6TH, 1942.

9 A.M. to 9-30 A.M. ..	Meetings of the Sectional Committees.
9-30 A.M. to 1 P.M. ..	Meetings of Sections.
9-30 A.M. ..	Presidential Address: Section of Geology: 'The Jurassic Rocks of Cutch—their bearing on some problems of Indian Geology.'
10-30 A.M. ..	Presidential Address: Section of Chemistry: 'Certain aspects of pure and applied Photo-chemistry.'
11-30 A.M. ..	Presidential Address: Section of Geography and Geodesy: 'Some aspects of the regional Geography of Kerala.'
12 NOON ..	Presidential Address: Section of Zoology: 'The urgent need for Biological Stations in India.'
11-30 A.M. to 1 P.M. ..	(1) Discussion on 'The utilization of results of agricultural research for increased monetary return to the cultivators.' (SECTION OF AGRICULTURE).
	(2) Discussion on 'Ship building industry and its possibility in India.' (SECTION OF ENGINEERING).

11-30 A.M. to 1 P.M. ..	(3) Discussion on 'Vocational guidance.' (SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE).
	(4) Discussion on 'The anthropological approach to the Indian sociology.' (SECTION OF ANTHROPOLOGY).
	(5) Discussion on 'Manufacture of synthetic drugs in India.' (SECTION OF CHEMISTRY).
2 P.M. ..	Meeting of the Sub-Committee on 'Science and its Social Relations.'
2 P.M. to 4 P.M	(1) Discussion on 'Factor Analysis.' (SECTIONS OF PSYCHOLOGY AND EDUCATIONAL SCIENCE AND MATHEMATICS AND STATISTICS).
	(2) Discussion on 'India's position with regard to sulphur resources.' (SECTIONS OF CHEMISTRY AND GEOLOGY).
	(3) Discussion on 'Control of Weeds.' (SECTIONS OF BOTANY, AGRICULTURE AND ENTOMOLOGY).
4 P.M. ..	Meeting of the General Committee.
6-30 P.M. ..	Popular Lecture on 'The Mica Industry,' by Dr. J. A. Dunn, D.Sc., D.I.C., F.G.S., F.N.I. Superintending Geologist, Geological Survey of India.

WEDNESDAY, JANUARY 7TH, 1942.

9 A.M. to 9-30 A.M. ..	Meetings of the Sectional Committees.
9-30 A.M. to 1 P.M. ..	Meetings of Sections.
9-30 A.M. ..	Presidential Address: Section of Entomology: 'Certain aspects of morphology of insects in relation to habit.'
10-30 A.M. ..	Presidential Address: Section of Engineering: 'Education for the Engineering Industry.'
11-30 A.M. ..	Presidential Address: Section of Psychology and Educational Science: 'Measurements in Psychology.'
12 NOON ..	Presidential Address: Section of Mathematics and Statistics: 'Sample Surveys.'
11-30 A.M. to 1 P.M. ..	(1) Discussion on 'Land utilization surveys in India.' (SECTION OF GEOGRAPHY AND GEODESY).

11-30 A.M. to 1 P.M. ..	(2) Discussion on 'Industrial Plastics.' (SECTION OF CHEMISTRY).
	(3) Discussion on 'Flow of fluids through beds of granular materials.' (SECTION OF ENGINEERING).
2 P.M. to 4 P.M. ..	(1) Discussion on 'Refrigeration in Cold Storage of Potatoes.' (SECTION OF ENGINEERING)
	(2) Discussion on 'Mineral Policy in India,' (SECTIONS OF GEOLOGY AND GEOGRAPHY AND GEODESY).
	(3) Discussion on 'Physical and chemical properties of clays and bentonites.' (SECTION OF CHEMISTRY).
4 P.M. ..	Meeting of the Executive Committee.
6-30 P.M. ..	Popular Lecture on 'Science and the National Reconstruction in India,' by Dr. Kewal Motwani, A.M., Ph.D.

THURSDAY, JANUARY 8TH, 1942.

9 A.M. to 9-30 A.M. ..	Meetings of the Sectional Committees.
9-30 A.M. to 1 P.M. ..	Meetings of Sections.
10-30 A.M. ..	Presidential Address: Section of Medical and Veterinary Research· 'Immunity phenomena in virus diseases.'
11 A.M. to 12-30 P.M. ..	(1) Discussion on 'Chromatographic analysis.' (SECTION OF CHEMISTRY).
	(2) Discussion on 'Linguistic provinces for India.' (SECTION OF GEOGRAPHY AND GEODESY).
6-30 P.M. ..	Popular Lecture on 'The Human Brain,' by Mr. Brij Mohan Lal, M.B.B.S., M.Sc. (Lond.), Principal, Osmania Medical College, Hyderabad.

Meeting of the Learned Societies

THURSDAY, JANUARY 1ST, 1942.

3 P.M. ..	Annual Meeting of the National Institute of Sciences of India.

FRIDAY, JANUARY 2ND, 1942.

2 P.M. to 4 P.M. .	(1) Annual Meeting of the Physiological Society of India.
	(2) Annual Meeting of the Institute of Chemistry of Great Britain and Ireland (Indian Section).

SATURDAY, JANUARY 3RD, 1942.

9-30 A.M.	..	Opening of the Indian Statistical Conference.
2 P.M. to 4 P.M	..	(1) Annual Meeting of the Society of Biological Chemists, India.
		(2) Annual Meeting of the Indian Physical Society.
		(3) Annual Meeting of the Indian Psychological Association.
		(4) Annual Meeting of the Entomological Society of India.
		(5) Annual Meeting of the Indian Botanical Society.

MONDAY, JANUARY 5TH, 1942.

2 P.M. to 4-30 P.M.	..	(1) Annual Meeting of the Indian Society of Soil Science.
		(2) Annual Meeting of the Society of Genetics and Plant Breeding.
3 P.M. to 4 P.M.	..	Annual Meeting of the Indian Chemical Society.

TUESDAY, JANUARY 6TH, 1942.

2-30 P.M.	..	Annual General Meeting of the Indian Pharmaceutical Conference.

WEDNESDAY, JANUARY 7TH, 1942.

1-30 P.M.	..	Annual Meeting of the Indian Ecological Society.

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